MILITARY HYGIENE

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From the Author

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A MANUAL OF SANITATION FOR SOLDIERS

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CONTENTS

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INTRODUCTION

HYGIENE is a term for a system of principles to preserve health, and sanitation is the practical application of such principles. The following pages are written to explain the bearing of those principles and their practice in the circumstances of military life, more especially since, by Army Order 3 of 1908, sanitation is a compulsory subject of examination for promotion to the rank of captain. No matter how we regard it, military sanitation has for its object the prevention of disease among soldiers. Further, inasmuch as disease produces absence from the effective ranks, be it by actual death or by sickness, or by the necessity of caring for the sick, disease prevention is synonymous with military efficiency. The introduction of this subject into the professional education of soldiers can be productive of nothing but good, in that military sanitation becomes thereby recognised as an essential factor in the whole art of war, while the possession of a knowledge of applied hygiene will afford one more qualification to command and supply one more agency of military effectiveness.

There is no intention by this book to attempt the conversion of every man into a medical expert; one can be artistic without being a painter, or one can indicate where a bridge or road should be without being an engineer, so a man should be sufficiently familiar with fundamental sanitary principles to avoid their gross violation and be able to accept at once technical advice, even if he fails to appreciate the premisses in detail. To that end this book is offered to the soldier, in the hope that it will enable him to take an intelligent interest in a subject which he has ignored too long, or at least regarded as being entirely within the sphere of activity of one particular corps. Such an attitude is absolutely wrong, and its perpetuation will be fatal to organised sanitary effort in the Army, whose only chance of success depends on the co-operation of all ranks.

Recognising that the essential object of military hygiene is the prevention of loss of efficiency as due to disease incidence, the first lesson to be learnt is to what extent disease has prevailed and contributed to military ineffectiveness in the past, and how much it prevails at the present time in the Army. The first chapter is devoted to a consideration of this question under the varying conditions of peace and war. The reader is next asked to consider the causes of disease, and to understand that, given healthy men of the military age, all preventable disease comes from without; is not spontaneous, but follows infection or the personal neglect of wholesome living. Further, as only under ideal conditions can we expect there to be no sickness at all, the sick-rate or morbidity furnishes an important index of military efficiency, and may be more effective in

controlling operations than the death-rate or mortality. In this sense it is conceivable that the mobility of a unit would be less interfered with by two hundred deaths after a few hours' illness from an acute disease like cholera, than by half as many cases of sickness, but no deaths, from a prolonged disease like enteric fever or dysentery. The great fact to be grasped is that sickness, whether in the camp or the barrack, means an expenditure of administrative energy, exaggerated by the demands of public opinion, which is willing to sacrifice many lives in battle, but unwilling to neglect anything that may comfort those falling from disease. Inasmuch as military hygiene aims, and is alone able, to remove this source of weakness, it is a positive and progressive science.

Having grasped the fundamental facts as to the causes of disease and the theory of its prevention, the reader is next asked to consider the material from which soldiers are made and to realise that not every chance applicant is good enough for the colours. Next, assuming the enlistment of intelligent and sound recruits, their physical training must be conducted in accordance with physiological teaching, and not by rule-of-thumb methods. Then follows the learning of details as to how soldiers should be housed, fed, clothed, and equipped. All of these topics have efficiency for their common object. Barracks, water, food, clothing, equipment, or forms of duty are conditions which maintain health as distinguished from restoring it; in this way they are methods of sanitation. These details may strike the young military student as trifling in comparison with the problems of

tactics, strategy, or fortification, and in a sense they are; but trifles make perfection, and cannot be ignored. The reader is next asked to consider the application of hygienic laws and principles to the circumstances of the march, the bivouac, and the camp. Here again apparent trifles have far-reaching effects, for, probably, nowhere does obedience to the laws of hygiene bear greater reward than in camp, and, conversely, nowhere is their violation visited with greater disaster.

Such, then, is the scope of military hygiene and the scheme of this book, wherein an endeavour has been made to explain the facts and the line of action which must be based on their recognition. As far as possible the use of technical language has been avoided, so that all should find it easy to understand what is the nature of disease and the methods for its prevention among soldiers. With the opportunity to live in accordance with the principles which are here inculcated, the soldier must stand or fall by his own actions.

CHAPTER I

MILITARY MORBIDITY AND MORTALITY

EVERY student of military history is aware of the close relation which exists between the health of an army and its efficiency as a fighting organisation; therefore, a knowledge not only of the extent of sickness and mortality therefrom in an army, but also of the causes and conditions which contribute by this means to its military inefficiency, is essential to every soldier. If we except the enhanced incidence of disordered action of the heart, the soldier cannot be said strictly to suffer from any disease to which the civilian is not equally liable. In both classes disease is mainly the result of environment, and, in spite of the special nature of their work and mode of life, we find that, in peace time certainly, soldiers suffer from much the same diseases as affect the civilian population living in their vicinity. In attempting to gauge the true incidence of morbidity and mortality among soldiers we must discriminate between the facts as relating respectively to peace and war.

HEALTH OF TROOPS DURING PEACE.

The earliest records regarding sickness and mortality in our own army upon which we can place any reliance

are those published intermittently during the period between the close of the Peninsular War and the outbreak of that in the Crimea. From these data we are able to construct the following table, showing the average amount of sickness and mortality among every 1000 men serving at each of the undermentioned garrisons during the periods specified :

Garrison.	Period or Year.	Annual Ratio per 1000 of Strength.		Period or Year.	Annual Ratio per 1000 of Strength.	
		Admitted as Sick.	Died.		Admitted as Sick.	Died.
United Kingdom :						
Household Cavalry	1830–1836	—	14·5	1837–1846	—	11·1
Cavalry of Line .		929	15·3		961	13·6
Foot Guards .		830	21·6		862	20·1
Infantry of Line		916	21·6		1014	17·9
Gibraltar . .	1818–1836	966	22·3	1837–1856	976	12·9
Malta . . .	1817–1836	1142	18·7	,,	1128	18·2
Ionian Isles . .	,,	1201	28·3	,,	1168	17·9
Bermuda . .	,,	1310	35·1	,,	1080	35·5
Canada . . .	,,	1097	20·0	,,	950	17·2
Nova Scotia . .	,,	820	17·8	,,	836	15·1
Newfoundland .	1825–1836	1143	37·7	,,	689	11·0
Windward Isles .	1817–1836	1903	81·5	1837–1853	1892	62·5
Jamaica . . .	,,	1812	128·0	1837–1855	1371	60·8
Sierra Leone . .	1819–1836	2978	186·0	,,	—	—
St. Helena . .	1816–1822	738	25·4	1837–1856	906	12·3
Cape, South Africa .	1818–1836	991	15·6	1838–1856	875	15·9
Mauritius . .	,,	1249	30·5	,,	909	24·0
Ceylon . . .	1817–1836	1678	71·9	1837–1857	1107	38·6
India :						
Bengal . .	,,	1577	75·6	1838–1856	2017	76·2
Madras . .	,,	1783	76·1	,,	1741	41·5
Bombay . .	,,	1451	62·8	,,	2117	60·9
Tasmania . .	,,	—	—	1839–1856	726	11·8
New Zealand . .	,,	—	—	1841–1856	529	12·7

Although no elaborate details are given in these early returns, sufficient information is afforded to show how enormous was the death-roll, not only in some of our foreign garrisons, but also at home, during the earlier years of the last century. For further information

concerning the sanitary condition of our army at that and a later period we are largely indebted to the Report on the Health of the English Soldiers quartered in England, published in 1858. From the facts given in that report it is evident that the mortality of soldiers at that time was something like two and a half times as great as the mortality of agricultural labourers, and about twice as great as that existing among indoor workers, such as printers. The chief causes of this excessive mortality in military garrisons were phthisis and other pulmonary affections due to overcrowding, defective feeding, faulty clothing, and other unhygienic conditions. The lessons so clearly demonstrated in that historic report were taken to heart, and, thanks to the initiation of a wise policy of sanitary reform, also the amelioration, not only of the housing of soldiers, but of the general conditions of service, a notable change for the better has resulted both in the total mortality among soldiers and in the non-effectiveness resulting from general disease prevalence. How far this favourable conclusion is warranted will be apparent from a study of our modern statistics relating to the health of the Army.

As a comparative statement, the accompanying table has been constructed to illustrate on these lines the varying incidence of disease and its effect upon efficiency in the Army for the two years 1859 and 1906, these being the earliest and latest periods for which reliable facts can be obtained. It will be seen at once that the figures show a marked improvement upon those already given as to the conditions existing before the Crimean War. But bearing in mind that the military service

represents a picked male population, and that those unable to maintain the required physical standard are rapidly eliminated, we are hardly justified in accepting them as the high-water mark of sanitary efficiency. Looked at in this light, there is every reason for

European Troops.	Ratio per 1000 of Strength.							
	Admissions for Sickness.		Deaths.		Invalided for Sickness.		Constantly non-effective by Sickness.	
	1859.	1906.	1859.	1906.	1859.	1906.	1859.	1906.
All troops at home and abroad	1120	590·9	18·2	5·61	16·0	15·0	58·0	36·18
United Kingdom	1028	448·8	8·9	2·73	13·0	18·2	60·0	26·40
Gibraltar	948	343·8	7·7	2·17	11·0	12·4	29·0	28·37
Malta	1213	644·8	19·0	8·32	9·0	9·4	52·0	46·21
Egypt and Cyprus	—	1878·2	—	25·10	—	11·6	—	103·72
Canada	545	259·6	10·4	2·99	15·0	13·16	28·0	16·72
Bermuda	537	327·6	13·9	4·65	7·0	10·14	35·0	22·32
Barbados	1050	1111·8	6·3	3·19	—	9·57	—	64·93
Jamaica	1335	793·5	14·4	3·62	4·0	9·06	58·0	85·58
St. Helena	802	627·4	13·0	7·60	—	0·00	36·0	32·00
West Africa	580	1117·1	25·0	4·20	—	21·01	—	55·21
South Africa	923	174·2	11·3	5·50	13·0	10·43	49·0	29·06
Mauritius	1236	911·6	16·1	20·64	11·0	8·84	49·0	54·83
India	1814	833·6	32·2	10·38	12·0	12·30	68·0	52·41
Ceylon	1693	655·4	35·0	12·26	9·0	12·26	70·0	39·26
China	2783	1690·2	59·4	10·25	89·0	20·41	169·0	107·70
Straits Settlements	—	991·1	—	8·87	—	15·02	—	49·67

further serious effort being made toward a reduction of total admissions for sickness and those dying from sickness. On the whole, we are disposed to think the figures for the United Kingdom distinctly good, and if we contrast the mortality at the present time among soldiers serving at home with that of the civil male population of corresponding ages, we find the ratio by no means unfavourable to the soldier.

The following statement is on a basis of a thousand males:

Period.	From 20 to 25 years.		From 25 to 30 years.		From 30 to 35 years.		From 35 to 40 years.	
	Civilians	Soldiers	Civilians	Soldiers	Civilians	Soldiers	Civilians	Soldiers
1855	8·1	17·0	9·2	18·3	10·2	18·4	11·6	19·3
1906	4·1	2·6	5·7	2·7	5·9	5·8	9·5	8·5

Satisfactory as these figures may be, there is no disguising the fact, however, that the same cannot be said with regard to white troops doing duty in tropical climates. It is not implied that there has been no improvement, for that there has been; but the statistics suggest that we are marking time rather than advancing. It is conceivable that climatic conditions in the tropics furnish obstacles against a constant reduction in rates proportionate to that which has occurred in home garrisons; still we must not remain content with the present conditions. Much remains to be done, and there is no reason to doubt that the current rates of disease incidence in more than one of our tropical and Colonial stations can be much reduced.

Not only has there been notable sanitary progress in our own army during the past generation, but the same has taken place in those of foreign Powers. In the German army the number of admissions to hospital has dropped from 1496 per 1000 in the year 1868 to 605 in 1905. In 1868 the annual death-rate per 1000 was 6·9; last year it was only 1·9. Very much the same story comes from France, where in 1885 the death-rate per 1000 was 7·8, while in 1905 the corre-

sponding ratio was 3·1; their admissions to hospital, per mille, were 1130 in 1885 and 660 in 1905. In the Italian army the death-rate per 1000 was 10·3 in 1885, but only 4·8 in 1905. In the army of the United States the admissions for sickness were 1402 per 1000 in 1885 and but 1250 in 1905, the corresponding death-rates being 7·3 and 6·1. The mortality in the Russian army at home was 3·2 per 1000 in 1905, with an admission rate of 325. In the Austro-Hungarian army the admissions for all diseases were 636 per 1000 in 1905, with a death-rate of 2·2.

The individual significance of the several diseases, which, taken together, determine the sanitary condition of our army in time of peace, will be readily appreciated by reference to the following table. Venereal affections, malarial fevers, and digestive troubles, mainly diarrhœa, give the highest admission rates for sickness, but the mortality from these causes is trivial. Enteric fever causes the highest ratio among the deaths, the next most fatal form of disease being pneumonia and other kinds of respiratory trouble. Among causes of invaliding from the service, the first place is taken by various affections of the heart, while a variety of other ailments, such as tuberculosis, respiratory diseases, debility, and affections of the nervous system, contribute in a marked but lesser degree. Judged by the numbers constantly sick, the chief contributing causes to non-efficiency are venereal diseases, digestive troubles, lung troubles, enteric and other continued fevers, rheumatism, and local injuries. It is noticeable that alcoholism is a minor

factor in increasing the rates for sickness, deaths, and non-efficiency.

Diseases.	Average Ratio per 1000 from 1897 to 1906.			
	Admissions.	Deaths.	Invalids finally Discharged.	Constantly Sick.
GENERAL DISEASES.				
Small-pox	0·2	·02	--	·03
Measles				
Scarlet fever	6·2	·04	·00	·46
Other eruptive fevers . .				
Plague	·0	·02	—	·60
Influenza	14·3	·03	·00	·52
Diphtheria	·6	·02	—	·05
Enteric fever	10·2	2·23	·05	1·63
Malta fever	22·6	·07	·04	1·17
Other continued fevers . .				
Cholera	·2	·17	—	·00
Dysentery	9·7	·29	·08	·73
Yellow fever	·0	·01	—	·00
Malarial fevers	108·2	·25	·19	1·10
Septic diseases	1·0	·07	·01	·07
Tubercle of lung	3·3	·66	1·66	·56
Other tubercular diseases .				
Syphilis	73·8	·10	1·14	7·12
Gonorrhœa	82·0	·00	—	6·31
Soft chancre	34·5	—	—	2·63
Hydrophobia	·0	·01	—	·00
Scabies	19·9	·00	·18	·73
Other parasitic diseases . .				
Scurvy	·1	·00	·00	·01
Alcoholism	3·0	·08	·01	·12
Rheumatic fever	24·3	·05	·67	1·72
Rheumatism				
Debility	14·1	·01	1·18	1·01
Other general diseases . .	5·7	·12	·26	·40

Diseases.	Average Ratio per 1000 from 1897 to 1906.			
	Admissions.	Deaths.	Invalids finally Discharged.	Constantly sick.
LOCAL DISEASES.				
Diseases of the—				
Nervous system: Nervous	7·7	·26	1·24	·55
Nervous system: Mental	1·6	·05	1·23	·31
Eye	11·6	·00	·98	·70
Other organs of special sense	11·1	·01	1·08	·72
Valvular disease of heart; Disordered action of heart; Other circulatory diseases	13·2	·52	4·11	1·36
Bronchitis; Pneumonia; Pleurisy; Other respiratory diseases	38·9	·96	·71	2·04
Digestive system	104·8	·81	1·70	4·09
Lymphatic system	14·7	·01	·10	1·63
Urinary system	2·5	·13	·37	·23
Generative system (except soft chancre)	13·5	·01	·29	·76
Organs of locomotion	12·6	·02	1·32	·86
Connective tissue	24·7	·01	·07	1 09
Skin	49·3	·00	·18	2·21
INJURIES.				
General	2·0	·65	·05	·10
Local	92·2	·49	·96	4·16
In action	·4	·00	·33	·04
No appreciable disease	3·5	—	—	·13
Poisons	·6	·07	·00	·03
Suicides	—	—	—	—
Cause unknown (refers to death only)	—	·01	—	·09

Branch of Service as affecting Health.—It is well known that soldiers of certain arms are more prone to disease than are others. This is usually explained by the character of the duties each is required to perform.

We question whether this is altogether adequate. The following figures indicate the numbers constantly sick per 1000 of strength in various branches of the service, as obtainable from the latest returns: In Household Cavalry, 28; in Cavalry of the Line, 35; in Royal Artillery, 23; in Royal Engineers, 19; in Foot Guards, 46; in Infantry of the Line, 26; in Army Service Corps, 21; in Royal Army Medical Corps, 19; in Army Ordnance Corps, 17. It will be noticeable that the highest rate of non-effectiveness is in the Foot Guards; this is due to the greater incidence of venereal disease among them, consequent on their being quartered in certain Metropolitan barracks. The Cavalry of the Guard, being more busily employed, appear not to be similarly influenced. The figures for the Cavalry and Infantry of the Line are curiously dissimilar, a fact which supports the generally accepted view that the mounted soldier has more arduous and risky work than the unmounted. As might be expected, the units showing the lowest non-effective rates are the technical corps, whose men are not only better paid, but also of a higher education and generally superior type.

Locality as affecting the Health of Troops.—The statistics for our army in time of peace are very illustrative of the effects of local conditions of climate, water, and environment. The following figures indicate the number of men constantly sick per 1000 of strength in the various commands at home for last year: In the London district, 49; in the Eastern district, 27; in the Irish command, 26; in the Southern command, 24; in the Aldershot and Northern commands, 23; in the Scottish command, 21; and in the Western and

Channel Islands commands, 17. For the whole United Kingdom the ratio in 1906 was 25, the average sick time to each soldier being nine days, and the average duration of each case of sickness being twenty days. When we look to the various commands abroad, we find that they arrange themselves into the following four main groups, namely, the garrisons of the Mediterranean Basin, South Africa, India, and "other garrisons." On this basis we can construct the following comparative table:

Troops serving in 1906.	Ratio per 1000 of Strength.				
	Admitted to Hospital.	Died.	Sent Home as Invalids.	Discharged as Invalids.	Constantly Non-effective from Sickness.
Mediterranean garrisons .	516	4·1	25·7	9·9	34
South Africa .	423	4·3	13·5	7·4	28
India . .	871	10·9	28·4	9·4	52
All other foreign garrisons .	694	6·4	32·7	10·3	43
United Kingdom	447	2·9	—	14·4	25

It will be readily seen how diverse climatic conditions affect the health of the soldier. The effect of foreign service is to increase all the ratios except that representing men discharged from the service. The total loss due to death is about trebled by foreign service, the increase being due mostly to the more acute forms of disease; thus, enteric fever in India, Malta fever in Malta, malarial fever in Mauritius, the Straits Settlements, and West Africa.

South Africa takes the first place for healthiness of all

the foreign groups. Except in the matter of deaths, it shows a marked superiority over the Mediterranean garrisons. The invaliding, both for change and as permanently unfit, is distinctly lower, while the constantly inefficient is from one-fifth to one-sixth less. As regards invaliding, the Mediterranean group occupies a position not much better than India, the total discharges being, in fact, slightly higher than in the latter country. The death-rate of India is, on the other hand, far higher than that of any other group, and makes the total wastage by death and discharge equivalent to about 20 per 1000, the highest of all the four foreign groups. The heterogeneous group of "other foreign garrisons" comes next with about 16 per 1000, the Mediterranean Basin with 14, and South Africa with 11 per 1000. As regards constant inefficiency due to sickness, India again gives the highest figure, being about 25 per cent. higher than the "other foreign garrisons," and 33 per cent. above the Mediterranean Basin.

Influence of Age and Length of Service.—The importance of these two factors as affecting the efficiency of soldiers, whether in peace or war, is common to all armies. In our own service, where men serve all over the world, the effects of both age and length of service are most striking. In the garrisons of the United Kingdom the sick admission rate is highest among men between twenty and twenty-five years of age, and lowest among men of forty years and upwards. The mortality rate is lowest among those under twenty years of age, and rises steadily in each quinquennial period. The invaliding rate at

home is greatest among those of thirty-five to forty years, and lowest among those of between thirty and thirty-five years of age. Individual year periods however, vary in regard to this fact, a disturbing influence being the occurrence of some small war. The most striking effects of age are shown, however, in the incidence of enteric fever; the following table refers to soldiers serving in India during 1906. The same also brings out the part which length of service in that country plays in the same connection.

Age.	Per 1000 of Strength. Admissions.	Per 1000 of Strength. Deaths.	Length of Service in India.	Per 1000 of Strength. Admissions.	Per 1000 of Strength. Deaths.
Under 20 years .	10·6	2·12	Under 1 year .	23·3	3·88
From 20 to 25 years	22·0	4·61	From 1 to 2 years	20·0	4·03
,, 25 ,, 30 ,, .	12·0	2·08	,, 2 ,, 3 ,, .	12·2	2·77
,, 30 ,, 35 ,, .	5·8	1·61	,, 3 ,, 4 ,, .	14·6	3·02
,, 35 ,, 40 ,, .	5·2	1·42	,, 4 ,, 5 ,, .	12·0	2·75
,, 40 upwards .	2·2	—	,, 5 ,, 10 ,, .	8·4	2·77

In the home garrisons the influence of length of service is equally manifest on the various rates for admission to hospital, invaliding, and deaths. For many years the highest admission rate from all causes has been among men with less than one year's service, and the lowest among men with eight years' service or more. Invaliding among men at home seems to be highest with those having from five to ten years' service; the lowest rates occur among men with one year's service. On the other hand, it is the men with the longest service who show the highest ratio of mortality

from all causes; while those with less than one year of service give the lowest.

Invaliding.—This is a form of waste which, as far as statistics go, is confined to the Army alone. In civil occupations a man who breaks down at his work merely swells the ranks of the unemployed, and his place is taken by another. There are no records of these men; therefore it is impossible to compare the effects of military life with those of civil life under this heading. Invaliding has, of course, an important effect on the death-rate of the Army. Men suffering from incurable disease leave the service as invalids, and if they die their deaths are recorded in the civil returns. It is difficult to say what the reduction in the military death-rate from this cause really is; much must depend on the actual circumstances of each case. In invaliding, therefore, we have an uncertain factor which merits serious consideration.

From 1880 to 1892 there was a steady fall in the invaliding rate from all causes in the Army; from that date there was a steady rise, culminating in the heavy ratio of 290 per 10,000 of strength in 1901, due in its intensity to the effects of the South African War. Since the war there has been a fall, and in 1906, or the latest date for which figures are available, the rate was 119 per 10,000. The chief causes of waste under invaliding are six, namely, diseases of the heart and circulation, tubercular diseases, nervous diseases, syphilis, digestive diseases, and rheumatism. At present the highest place in the invaliding list is held, as it always has been, by diseases of the circulatory system. Under this head the main cause of wastage is dis-

ordered action of the heart, due, as will be explained in another section, to a defective and too hurriedly forced system of physical training of immature and often ill-fed lads, coupled with the obnoxious habit of smoking inferior tobacco in cigarettes. As a source of military waste, syphilis has shown a tendency to fall in recent years. This diminution must in a large measure be attributed to the extension of temperance in the Army. The loss under this head is now 7 men out of 10,000 serving. Diseases of the digestive system hold a considerably higher place in the invaliding list than used to be the case. This increase is explicable by the greater attention now paid to the soldier's teeth. The most gratifying feature of the invaliding question is the fall in tubercular diseases. The present ratio is about 16 per 10,000 of strength. The other causes of invaliding call for no special remark.

The loss due to discharge as invalids is not increased by foreign service. This is due to two main causes: the first, that the men who go abroad are carefully inspected before selection for foreign service, and the obviously unfit or unsound are retained in this country, thus not only relieving the foreign invaliding rate, but possibly adding to that of the troops serving at home; the second, that a considerable number of men are sent home from abroad for a change who are still able to remain in the service, who would be lost to it if they had not received the advantage of an early change of climate. About 25 men per 1000 of all serving abroad are sent home annually. Of these some 9 are discharged as unfit. This leaves a balance of about 16 per 1000 retained. Although the total wastage from the Army

is not materially affected by foreign service as a whole, the death-rate is distinctly enhanced thereby. As regards constant inefficiency, the effect of foreign service is to raise the numbers constantly sick from 25 to 43 per 1000. In other words, every man at home is inefficient by sickness for 9 days in the year, and every man abroad for 16 days. The balance in excess, or 7 days, represents the loss to the State due to foreign service.

Death-rates.—In a previous section the actual death-rates of troops in our army serving in various geographical areas have been given; the following table may be of interest as showing the mortality from particular diseases or groups of diseases among soldiers serving in various places as compared with the civil population at home of the soldier's age. From these figures it is apparent that the health of the Army at home is superior to that of the civil male population of similar ages; but, as has been pointed out already, the influence of invaliding in the service invalidates any general conclusion that could be drawn from a consideration of death-rates alone. It is noticeable that both the enteric fever and tuberculosis death-rates in the Army at home are distinctly lower than the corresponding rates for civilian males.*

Comparative Value of Military Medical Statistics.—Of all the ratios which are given in military medical statistics, the more important which

* The reader must bear in mind that military medical statistics like those of civil life, vary from year to year; therefore the student should consult the annual report of the Director-General of the Army Medical Service on the health of the Army. This book is officially published early in each year.

—	Deaths per Million.					
	British Soldiers serving in					Civilian Males of the Soldier's Age living in England and Wales.
	United Kingdom.	Mediterranean Garrisons.	South Africa	India.	Other Foreign Garrisons.	
Enteric fever	88	450	1000	3190	519	168
Tuberculosis	305	560	175	273	612	1761
Alcoholism	32	150	62	91	185	39
Diseases of the heart	217	82	103	111	66	322
Diseases of the circulatory system	112	105	110	126	86	57
Diseases of the respiratory system	627	—	—	63	108	476
Diseases of the digestive system	289	—	390	1975	761	222
Injuries and suicides	498	603	1112	1582	853	589
All other causes	750	2122	1334	3401	3194	888
Total	2918	4072	4286	10,812	6384	4513

serve to determine the healthfulness or otherwise of an army are: (*a*) the admissions for sickness, (*b*) the losses by death, (*c*) losses by invaliding out of the service, and (*d*) the numbers constantly sick. A consideration of any one of these rates alone is wholly unreliable; this is particularly the case in regard to the rates for admissions to hospital and for those constantly sick. The latter is obviously dependent upon the former, and both are the direct outcome of the degree of stringency in force as to when a man is placed on sick-report. The admission rate invariably attracts attention owing to its magnitude, but, as explained, it does not of itself imply necessarily a very great prevalence of disease. In a similar way, neither the death-rate nor the invaliding rate alone should be taken as indices of comparison between several commands; the death-rate can be reduced by the removal from the service of those affected with or predisposed to disease; in other words, a high invaliding rate may secure a low death-rate, and *vice versâ*. The fairest index of comparative non-effectiveness is probably represented by the sum of the non-effective loss as represented by the losses by death and invaliding. Such a figure is always high for the United Kingdom; this is due to the elimination of young soldiers within three months of enlistment, consequent on their showing evidence of not being likely to become efficient. Virtually, the invaliding rate is the controlling factor in determining the value of the various other rates, while it is itself dependent largely on the physical standard to which the recruit, before enlistment, is required to conform. When we remember, further,

that the requirements for discharge are influenced by the rules or customs of each military service and by the personal equation of each medical officer, the difficulties in the way of taking even this ratio as a standard of comparison between armies or commands are considerable.

If we attempt to compare the health of the British army with that of foreign armies, we find that, taking all diseases, the army of the United States heads the list with the enormous admission rate of 1250 per 1000 of strength. After this come the French, German, and Austrian armies, with rates all above 600. Fifth in the list is our own army serving at home, and lowest of all is the Russian army, with the low figure of 325 admissions per 1000. Too much stress must not, however be laid on these figures, as they are to a great extent dependent on the regulations as to out-patient treatment and other service customs, which vary considerably in different armies. As regards death-rates, we find, again, that the American army leads with a ratio of 6·14 per 1000; the British and French armies come next, with a figure about half that of the above; the lowest of all is the German army, with a ratio of 1·9. These figures also are liable to be affected by the customs of the different services, though less so than the admission rates. The high death-rate (3·2) of the Russian army as compared with its low admission rate points to a considerable use of the out-patient system in that army.

Taking individual diseases, we find that as regards enteric fever the French army suffers by far the most of all the armies of Europe, its admission rate of 14·1

per 1000 being not much below that of the British army in India, namely, 15·6 per 1000. The Russian and United States armies come next with 3·8 and 3·57 per 1000; then the Austro-Hungarian and German armies; while the British army at home occupies the lowest place. In respect of the death-rates from enteric fever, the same relative positions are more or less maintained, though the Russian army shows a death-rate on admissions of nearly 20 per cent.

If we take venereal diseases, the highest rate prevails in the American army, the ratio being 179 per 1000, as compared with the corresponding ratio of 82 in the British army at home. The French and Austro-Hungarian armies, with rates of 67 and 62, come next, followed by the Russian army, while the German army, with a ratio of 20 per 1000, is last. As regards tuberculosis, France and the United States again have the highest rates, namely, 5·3 and 4·7 per 1000 respectively; the British and Russian armies have ratios of less than half these figures, while Germany and Austro-Hungary come last with ratios about one-half of those of the English and Russian armies. Diseases of the heart are much more prevalent in the home forces of Great Britain than in any other army, the admission rate being 7·3 per 1000 of strength; America and Germany come next with ratios of 3·8 and 3·5, France and Russia give a more or less identical figure of 2·5, while in the Austro-Hungarian army the rate is but 1·9 per 1000. In regard to both tuberculosis and cardiac diseases, too much stress must not be laid on these comparative figures, since in some armies the hopeless cases are retained, while in others they are

sent to their homes to swell the statistics of the civil population.

Health of Troops in Time of War

Hitherto, it must be said, the morbidity and mortality rates of armies in the field have not been very creditable to military sanitary administration, as it is difficult to cite campaigns in which the death-rate from sickness has not been greater than that from casualty; but, on the other hand, it must be remembered that the circumstances of service in the field render sanitary effort extremely difficult.

The rates for sickness and death in regard to some of our earlier wars are difficult to obtain, owing to faulty statistical methods and absence of reliable records. Perhaps one of the most notoriously mismanaged campaigns in our history was the Walcheren expedition of 1809, in which the mortality from disease was 347 out of every 1000 men on strength, while only 16·7 per 1000 were killed by the enemy. In the Peninsular War we lost three times as many men by disease as by the acts of the enemy, and the sick-rate was so great that it was estimated that more than twice the number of the whole army passed through the hospitals during the year. In the Crimea our mortality from disease amounted to a ratio of 230 per 1000 of strength, while our losses from wounds were practically 150 per 1000. Confining our attention to more recent experiences, especially in the various tropical and subtropical expeditions, which constitute so large a part of our field service, the following table shows some facts concerning European troops.

Owing to faulty methods of tabulation, some difficulty has been experienced in marshalling the figures as to the earlier minor wars in a manner comparable to those of more recent date, but as far as possible the difficulty has been overcome, and the table may be accepted as an

Expedition or War.	Ratios per 1000 of Strength.					
	Admissions.			Deaths.		
	For Disease.	For Wounds or Injuries in Action.	Total.	From Disease.	From Wounds or Killed in Action.	Total.
Ashanti, 1873–1874	474·0	70·0	544·0	16·00	6·0	22·00
Perak, 1875–1876	227·0	1·6	228·6	20·00	1·6	21·60
Zululand, 1879–1880	739·0	12·0	751·0	24·83	1·8	26·63
Afghanistan, 1879–1880	869·9	51·0	920·9	36·03	6·92	42·95
Egypt, 1882	554·0	29·0	583·0	6·06	7·15	13·21
Sudan, 1884	76·2	49·2	125·4	—	31·36	31·36
Nile, 1884–1885	808·6	22·4	831·0	40·01	11·70	51·71
Suakim, 1885	282·9	13·7	296·6	7·87	6·50	14·37
Sudan, 1885–1886	1100·3	16·9	1117·2	29·44	9·82	39·26
Nile, 1889	73·5	3·3	76·8	1·31	0·65	1·96
Ashanti, 1895–1896	19·27	—	19·27	0·56	—	0·56
Chitral, 1895	1530·00	14·0	1544·00	49·39	5·10	54·49
Dongola, 1896	976·60	—	976·60	81·70	—	81·70
Bechuanaland, 1896	531·00	11·0	542·00	28·60	2·6	31·20
Mashonaland, 1896	782·00	53·0	835·0	3·80	15·0	18·80
Tirah, 1897–1898	573·8	25·6	599·4	28·24	2·67	30·91
Nile, 1898	1101·7	56·7	1058·4	36·18	15·67	51·85
China, 1900–1901	1051·7	10·2	1061·9	22·71	2·35	25·06
South Africa, 1899–1901	746·0	34·0	780·0	69·00	42·00	111·06

accurate summary of the facts. It will be seen at once that the degree of disease incidence, as well as the amount of losses sustained from acts of the enemy, has varied immensely. This is not to be wondered at, considering the diversity of conditions under which these little wars or expeditions have been conducted. The most striking feature of these statistics is the marked

excess of the sickness admission rates over those for injuries received in action. Roughly, it may be said that for each man admitted to hospital for some wound or injury there are twenty-five admitted for some form of disease. The disparity is less marked in the corresponding death-rates, but even there it is quite the exception for the deaths from action effects to be in excess of those from disease. The usual ratio is five deaths from disease for one from wounds or injury.

Although most of the diseases occurring commonly among soldiers during peace are met with in war-time, still there is a marked tendency for some to predominate, notably those dependent upon such influences as exposure to climate, pollution of soil or water, and indifferent food. The influence of hostilities shows itself mainly in increased incidence and mortality from respiratory and digestive troubles, malaria, diarrhœa, dysentery, enteric fever, and cholera. The precise degree of increased incidence which these diseases display naturally varies according to the climatic and other circumstances under which any particular campaign is prosecuted. This is particularly the case in our own army, which serves all the world over; but in general terms it may be said that war conditions usually mean a sixfold increase of such diseases as diarrhœa, dysentery, and enteric fever, as compared with peace-time incidence; malarial fevers are increased about one-fifth, venereal diseases in camp life drop to about one-fourth of the number in ordinary garrison or cantonment; respiratory and digestive affections generally show a slight increase; while injuries, other than those received in action, together with other common

disabilities, do not as a rule prevail more than under circumstances of peace.

The closer one scrutinises the medico-sanitary statistics of forces in the field, the more one realises how large a part the so-called preventable diseases still play in rendering an army non-effective. Take, for instance, our recent experiences in South Africa. In that three years' campaign we are obliged to admit that no less than one-tenth of the admissions on account of disease were for enteric fever, and one-fourteenth were for dysentery, or these two diseases alone were the cause of practically one-sixth of the total admissions to hospital, and about two-thirds of the total deaths on account of disease; these two diseases accounted also for nearly one-half of the total losses by death from all causes during the war. The sanitary significance of these figures needs no argument. In the following chapters it is proposed to review and explain the principles and practice by which we can hope to prevent the recurrence of a similar result in any future field force.

CHAPTER II

THE CAUSES OF DISEASE

THE prevention of disease depends largely on a knowledge of its causes. If we look closely into the nature of the chief diseases, we find that they can be divided, roughly, into the following groups: (1) Diseases which are the result of some inherited defect or fault in the make of the body, (2) diseases which are the result of accident or injury, (3) diseases which are the effect or result of climate, (4) diseases which are due to either foolish habits or faulty modes of life, and (5) diseases due to some cause or causes introduced into the body from without.

So far as soldiers are concerned, we may say that the first group does not apply, as all soldiers are medically examined before they enlist, and no men become soldiers who have body defects likely to give rise to sickness or disease. The second group we may dismiss as largely non-preventable; accidents and injuries are bound to occur occasionally, even in a well-regulated army. Of the diseases caused by climate or weather, it is doubtful whether there are many, the chief one occurring among soldiers being sunstroke or heatstroke. In the fourth group are such diseases as the various venereal affections, alcoholism, and those forms of sick-

ness the result of the abuse of both drink and food. In the last or fifth group are diseases like enteric fever, cholera, dysentery, small-pox, plague, malaria, and a number of others, all of which are caused by the entering into the body from without of the cause, which is a living thing or germ.

It is quite clear that, from the nature of their causation, the various diseases included in the last three groups are more or less preventable. Thus, sunstroke and heatstroke can be avoided by the exercise of reasonable care in safeguarding the head from the effects of the direct rays of a powerful sun, and otherwise protecting the body from the effects of excessive heat. In the same way, venereal diseases can be avoided by the exercise of chastity and self-control; while, too, the effects of excessive eating and drinking are to be controlled by self-discipline, moderation, and common sense. The avoidance and prevention of the diseases in the remaining group is not quite so simple, and involves a consideration of the nature and mode of action of the germs or living things which are their cause.

Microbes or Germs.—The size and shape of the living things which are sometimes called germs or microbes, and which are the cause of a number of diseases, varies; their size may be anything from one fifty-thousandth to one ten-thousandth part of an inch, and their shape may be equally variable. Some are merely minute spherical granules, to which we give the name *micrococci;* others, from their rod-like shape, are known as *bacilli;* whilst others, having a corkscrew or spiral form, are known as *spirilla.* All these various forms are sometimes spoken of as *bacteria,* but, no

matter what is their shape or size, these various germs or microbes are living things and capable of producing others of their kind. The process of reproduction amongst the micro-organisms is generally a very simple one, and takes place under favourable conditions with enormous rapidity. The spherical micrococci and the majority of the bacilli and spirilla merely divide into two. In other cases, however, the bacilli multiply by the production within their substance of a round or oval bead-like body. This is known as a *spore*, or seed, and from it grows in due time another bacillus. These spores of bacteria are the hardiest forms of living matter of which we know, being able to resist extremes of heat, cold, and drying, conditions which would be immediately fatal to the parent bacilli from which they have sprung.

It must not be supposed that all bacteria or germs are hurtful and capable of producing disease; it is far otherwise. The majority of micro-organisms do good, and we could not carry on our lives without them; it is only a small number which are harmful to man and able to cause disease. Should, by chance, these disease-producing germs or bacteria gain access and a foothold, as it were, in man's body, they grow and increase in numbers. Sometimes they prefer to grow in the blood, at other times in the lungs, or spleen, or liver, or the bone-marrow, while sometimes they prefer to grow inside the bowel, or perhaps outside the body, on the skin or in the roots of the hair. The greater number of the disease-producing germs live and thrive in the blood and other juices of the body. While growing and multiplying there they make or excrete a poison,

or *toxin*, as it is called, and it is the circulation of this poison or toxin in the blood and body juices which makes a man ill and gives rise to the various symptoms of the particular disease which is being caused. Whether a person is going to recover or not from the effects of the growth of the disease germs in his body depends upon how well, or how successfully, he can manufacture an antidote or corrective to the poison made and poured into his system by the germs. If sufficient of the antidote is made, then the germs are gradually killed and their poison neutralised, followed by the gradual recovery of the sick person. If, on the other hand, the germs make so much of the poison or the patient fails to make sufficient antidote to neutralise the germ poison, then he dies as the result of the disease caused.

This behaviour of these disease-producing germs in the human body is very similar to the action of yeast or other ferments when growing in sugary solutions such as malt and water, or apple-juice or grape juice. From these sugar solutions are made respectively beer, cider, and wine or brandy. Consider the latter case for a moment. The vintner takes the ripe grapes and throws them into a vat or tub. By crushing them up he makes a sugary liquid, into which pass various microbes, either from the air or by means of the skins of the grapes which are in the sugary mass. Certain of these germs or microbes from the air or attached to the grape skins ferment the sugar—that is, split it up into carbonic acid gas and alcohol. This action of the ferment goes on until sufficient alcohol has been made so as to constitute 14 per cent. of the sugary juice. When this

amount of alcohol has been formed, fermentation ceases, owing to the excess of alcohol. This is very much the same as occurs in the human body when certain of the disease-producing germs gain access to it; they go on growing and fermenting, as it were, in the blood and juices of the body until the body has manufactured a sufficiency of the antidote to stop their action. It is this curious resemblance between the two processes that has suggested the name of "fermentation-like" for many of these diseases, simply because their germs or causes behave in the human body like a ferment. Typical examples of diseases of this nature are small-pox, chicken-pox, measles, scarlet fever, enteric fever, plague, cholera, typhus, diphtheria, and many others. In all of them there is the introduction of a living germ or germs; then a period of "incubation" or hatching, in which nothing can be observed; then follows the active disturbance; and in the diseases, as well as in the fermentation of the sugary liquid, the process is stopped when the microbes have multiplied to a certain extent, a temporary or permanent protection being the result. Another name for diseases of this kind is "infective." A disease like small-pox or measles, which can be passed from person to person without immediate contact between the two, is termed infectious. In these cases the infection is conveyed by mucus expectorated or by dust blown about, or carried in clothing, &c., from the first patient. Such diseases may also, of course, be communicated by direct contact. If direct contact between the sick and well is indispensable for the conveyance of a disease it is called "contagious." In nature there is no such hard line drawn between

infection and contagion, although some diseases can be more easily communicated than others. In this sense, then, the word infective includes all the germ-caused diseases, however spread.

Throughout the progress of these diseases, except in the period of incubation, the patient is able to communicate his disease to persons about him who have not been rendered safe by a previous attack. The way in which he thus communicates his disease varies in different cases. In scarlet fever the throat, nose, ears, and skin are the chief sources of contagion; in diphtheria, influenza, measles, and whooping cough the secretions from the throat and respiratory passages; in enteric fever and cholera the urine, stools, and vomit. The protection afforded by one attack of an infective disease against its recurrence varies greatly; speaking generally, the disease occurs but once, but second attacks are not uncommon.

Means of Infection.—The modes by which infection is received vary greatly with different diseases. The chief channels of infection are the skin and the mucous membranes, particularly of the digestive and respiratory tracts. This means that man can contract infection by means of cuts, scratches, or wounds of the skin (inoculation), by means of the air, and by means of food and drink. Under this latter head milk and water are the two usual sources of infection, but uncooked food, especially oysters and mussels fed in sewage-polluted waters, may produce the same effect. Cholera, enteric fever, and dysentery are the chief diseases from this source. Milk may be infected from having been handled by an infectious person, or it may

convey infection of some disease from which the cow at the time is suffering, as, for instance, tuberculosis. Water may be contaminated with sewage or the excreta of a single infectious patient. When the air acts as a conveyor of infection, the infectious matter must generally be in the condition of dust. In this manner the contagion of small-pox can be carried considerable distances, that of tubercle possibly only a short space, and that of typhus but a few feet. Of diseases spread by inoculation or damage to the skin notable examples are tetanus or lock-jaw following the fouling of wounds with earth, malaria and yellow fever resulting from bites of mosquitoes, plague from bites of fleas from rats, and sleeping-sickness from the bites of a special fly found in various parts of Africa.

Susceptibility to Infection.—It may be asked, naturally, if, then, these disease-causing germs are so widely scattered and can reach man in such a variety of ways, why is it that man is not infected oftener than he is? The answer is that persons vary in susceptibility to attack by different infective diseases; moreover, the possibility and intensity of an attack depend on the condition of the person, and on the number and the virulence of the particular microbes infecting the person. The main protection against infection by germs exists in man's own body, more particularly in the blood, whose white corpuscles swallow up and destroy a certain number of bacteria after they have been damaged by means of a chemical substance dissolved in the watery part of the blood. This protective action varies in different persons, and in the same person at different times, the most important disturbing factors being age,

fatigue, injury, exposure to climate, and errors in eating or drinking. As long as a person keeps fit and leads a wholesome life under wholesome surroundings, this protective action is at its best; but when the vitality of the individual is lowered or the dose of infection is excessive, then the protection is proportionately overcome. The influence of age upon liability to infection by certain diseases is well known, notably in respect of enteric fever, which prevails more among young adults than among those of maturer age. So, again, fatigue plays a large part in rendering men susceptible to infection, especially that of enteric fever. This has been demonstrated experimentally, and there can be no doubt that much of the excessive incidence of this disease among young soldiers on field service can be explained by their greater susceptibility following exhaustion, fatigue, and the general stress of campaigning. The same can be said of both injury and exposure to variation or change of climate. We see this constantly in the greater prevalence of enteric fever among new arrivals in India. This is not the result of chance, but the outcome of their translation from a temperate to a more or less tropical climate, whereby their physiological equilibrium is profoundly disturbed, involving a corresponding loss of their natural ability to resist infection. Among the various dietetic errors and indiscretions which sensibly lower the vitality and healthy condition of the human body, the foremost place must be given to alcoholic excess. The number of persons who contract infection by germs following the abuse of alcohol is much larger than many suppose, and in support of this view many interesting experiments have been made on

animals. Thus, the disease-resisting power of the dog and pigeon against tetanus bacteria is so great that even large injections of these germs do not affect them; but both the dog and the pigeon are quickly killed by tetanus if twenty hours before injecting the bacteria the animal or bird be given a dose of whisky. In the same way, certain breeds of sheep are unaffected by anthrax germs, but this power to resist infection by this disease is taken away from the sheep by giving them alcohol.

CHAPTER III

THE CHIEF PREVENTABLE DISEASES OF SOLDIERS

In the following consideration of the diseases of the soldier it is obvious that only such affections as exert a definite influence on military efficiency and are at the same time preventable require discussion. In a previous chapter the nature and extent of military morbidity and mortality have been explained; in this section it is proposed merely to outline the more important features in the natural history of the chief diseases of the soldier, so that any policy for their prevention may be intelligible.

Venereal Disease.—Of all the preventable diseases from which the soldier suffers, venereal is the one which affects his efficiency to the greatest extent. This is especially so in our own army. The latest available returns show that, expressed as a ratio per 1000 of strength, all venereal diseases prevail to the following extent in various armies: British army at home, 82; British army in India, 115; British army in Colonial garrisons, 220; United States army, 178; French army, 67; Austro-Hungarian, 62; Russian, 45; German, 20. In connection with these figures it may be stated that, with the exception of the United States and British

armies, in all some special regulations are in force for preventing the spread of venereal affections. Under the general heading of venereal disease are included three distinct affections, namely, syphilis, gonorrhœa, and soft chancre. All are due to infection by certain microbes or germs communicated by persons already infected. The three diseases have not, however, the same serious significance to the sufferer, though all are contributory to military inefficiency.

Syphilis is a constitutional disease caused by the entrance into the body of a special germ, which has only recently been recognisable under the highest powers of the microscope. The infection, though slow, is very persistent, and requires a long course of treatment to secure complete recovery. The disease is characterised by three stages, namely, a first stage, marked by the presence of a sore or ulcer, usually on some external part, which is really the point or place of inoculation; then follows the constitutional infection, marked by the eruption of a rash on the skin; frequently, if treatment be vigorously and persistently followed, no further manifestations of the disease occur, but if neglected a third stage supervenes in the course of a few years, characterised by certain nervous troubles and the growth of tumours in various parts of the body. These later forms of the disease are rarely seen in the Army, and, thanks to improved methods of treatment, are becoming much less common than formerly.

The prevalence of syphilis varies in different commands. Expressed as a ratio per 1000 of strength, it prevails to the following extent: In the United Kingdom, 28; Gibraltar, 12; Malta, 10; Egypt, 38; Cyprus,

105; West Africa, 70; Mauritius, 50; South Africa, 20; China, 30; and India, 28. Although the usual source of infection is sexual intercourse, it must be understood that this is not the only means, and not infrequently the smoking of a tobacco-pipe used by a diseased man has given syphilis to another. Similarly, the infection has been passed by means of a kiss. The only true prevention or safeguard against this disease is abstention from immoral intercourse with women, but, having regard to the relative slowness of infectivity, scrupulous cleanliness and free lavation after connection are to some extent a preventive of infection. The great seriousness of this disease lies not so much in the effect which it has upon military efficiency while the man is still serving as upon the risks attaching to transmission of the infection by him to children, should he marry or produce offspring before he has been cured of the disease. This aspect of the question needs to be systematically put before the soldier, for few, as young men, realise the broader issues involved or their personal responsibilities to the race as citizens.

Gonorrhœa, although causing more non-efficiency than syphilis, is much less far-reaching in its effects. It is caused by a germ which sets up a specially virulent inflammation in certain parts, and may occasionally give rise to a troublesome form of rheumatism. Want of personal cleanliness, or the use of a towel or handkerchief belonging to a man with gonorrhœa, has caused an infective inflammation of the eye, leading to its total destruction. A not uncommon remote effect of this disease, manifesting itself late in life, is stricture. Among each 1000 men serving, 40 suffer from

gonorrhœa in the United Kingdom, 65 in Malta and Gibraltar, 90 in Egypt, 100 in West Africa, 170 in Mauritius, 70 in Ceylon, 120 in China, and 60 in India. The only preventive for this disease is abstention from intercourse with immoral women; ordinary cleanliness and washing after connection affords but a slight chance of preventing infection. In the Austro-Hungarian army, by the Order of May 1, 1907, men are encouraged, but not compelled, to use a 1 in 1000 solution of corrosive sublimate for ablution and a 3 per cent. solution of albargin for urethral injections. In the neighbourhood of the entrance to barracks a room is provided with the necessary equipment, solutions, &c., and the men are instructed in the advantage of their use. A register is kept, and the men enter their names, with the day and hour of using the preventives. In every case of venereal disease a note is made whether the man has used the preventives or not. In some garrisons this system is said to have effected a decrease of 62 per cent. in the cases of venereal disease. A general report on the results of the working of this system over an extended period is promised by the Austro-Hungarian War Office.*

The other form of venereal disease, known as soft chancre is essentially a local disease, causing only ill-health while the sore lasts. It is caused by a germ, and, like gonorrhœa, is a fruitful source of buboes or abscesses, in the groin. Infection is obtained only by immoral intercourse with women; the preventive measures are the same as explained for syphilis. This form of venereal disease appears to be most prevalent in West

* *Wiener Med. Wochenschrift*, No. 49, 1907, p. 2325.

Africa, Egypt, Gibraltar, and the Straits Settlements. In the majority of our garrisons there are from 15 to 40 cases per 1000 of strength.

Malaria.—Under the names of ague and "fever," the various types of malarial fever are the cause of much inefficiency among soldiers at all times in most of our foreign garrisons. These forms of fever are particularly severe in West Africa, South China, and India. During last year among each 1000 men serving there were 50 cases in Ceylon and North China, 75 in Crete, 150 in Mauritius and the Straits Settlements, 190 in India, 325 in South China, and 180 in West Africa. Malarial fever is caused by a minute organism or germ which develops and matures in the red corpuscles of the blood. In fact, this germ of malaria may be said to destroy the red cells of the blood, producing at certain fixed periods immense numbers of young forms, which escape into the blood and at once attack or invade fresh healthy red corpuscles. The actual attacks of ague and fever practically correspond or synchronise with the liberation of these young forms and the reinfection of the blood cells by them. The ague fit may occur daily, every other day, every seventy-two hours, or irregularly, according to the type of germ which has been acquired. In other words, these varying periods of time correspond to the precise periods which the particular species of malarial germ takes to complete its existence in the blood corpuscle and set free young forms.

The incubation or hatching period of ague or malarial fever varies from one to three weeks. Once it has developed, the disease presents three successive stages: (*a*) A cold stage, during which the sick person looks

and feels very cold, shivers, often vomits, and craves for warmth. This stage may last for an hour or less. (*b*) Gradually the patient is conscious of returning body warmth, feels very hot, and has a flushed face. This is the hot stage, and may last for four to six hours. (*c*) Then follows the sweating stage, in which there is profuse perspiration, with a sense of relief, and temporary recovery from the attack. The attack, however, returns at its appointed time, according to the type of germ in the blood. These various stages are not always definitely marked, often the cold stage being very slight and the hot period prolonged, or *vice versa*. These irregularities are particularly frequent in persons who have been taking quinine. In what is called remittent fever, and certain malignant types of malaria, the attacks are most irregular, and the fever lasts for a longer time than in ordinary or simple ague. Repeated attacks of malaria are very debilitating, and the cause of much invaliding of soldiers. It is rare for malaria to cause death, but in bad cases the patient may be ill for years before he makes a complete recovery, and that can only occur provided he is removed from all possible sources of reinfection.

The infection of malaria is acquired only in one way, namely, by the bite of an infected mosquito. This means that in a mosquito-free country a man affected with malaria is a source of no danger to any one; but in a mosquito country that same man is a certain source of infection to others. The transference of the infection from man to man happens in this wise: A man who suffers from ague or malaria has malarial germs in his blood; on being bitten by a mosquito, some of his

blood is sucked by the insect, and in certain species of mosquito, which are very common in India and other tropical countries, the malarial germ undergoes definite stages of further development, until it assumes the form of a most minute thread or filament, lodged in the salivary gland of the insect situated at the base of its proboscis. This infected mosquito, on sucking blood from another man, causes some of its saliva, containing the thread-like malaria germs, to pass into the person's

FIG. 1.

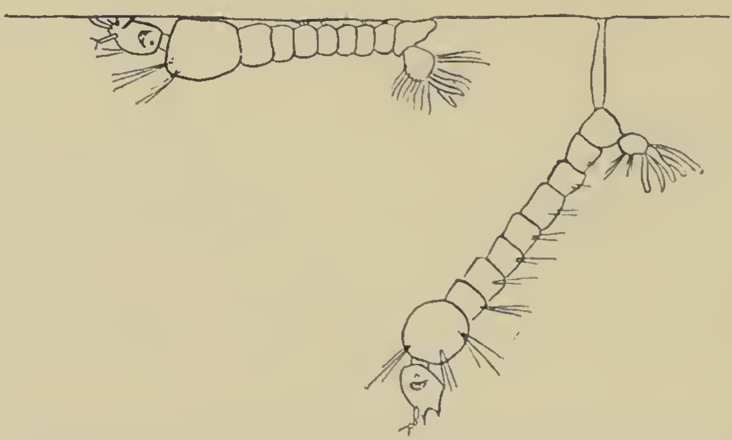
Showing resting attitude (A) of malaria mosquito, and (B) of the harmless mosquito.

blood, whereupon the germs at once attack or invade the red corpuscles, and thus start the infection in the mosquito-bitten person. The period of development of the malarial germ in the mosquito varies from eight to ten days, during which time the insect is flying about as usual. The various mosquitoes which can convey the germ of malaria from man to man—that is, enable it to undergo the requisite changes in development—all belong to the family known as *Anophelina*. This family contains many genera, found either in hot climates or the warmer regions of temperate climates. Anophelines may be told from other mosquitoes and gnats by the combined characters of the long palpi in both sexes, the total absence of flat scales on their chest, and their

straight proboscis. Many species have spotted wings, and when stationary are at an angle to the resting surface, the head, thorax, and abdomen being in one line. There are, however, some exceptions to this rule (Fig. 1).

In common with all other insects showing complete metamorphosis, the mosquito passes through four

FIG. 2.



Showing usual attitude assumed by larvæ of Anopheline and harmless mosquitoes in water.

stages—the egg, the larva, the nymph, and the perfect insect. Almost all mosquitoes are aquatic in their larval and nymph stages; hence any small collection of water may form breeding-grounds for these insects. The eggs are laid on the surface of the water, and if submerged will not hatch out. After a few days the eggs hatch out into larvæ. The long, legless larva has a flattened head, with a broad thorax, on which there are bristles, and a segmented abdomen with lateral bristles. The air or breathing apertures are placed dorsally at the hinder part of the abdomen; in the Anophelina they

are close to the surface of the body, but in the majority of other kinds of mosquito larvæ the air-hole is on the free end of a tube. On the arrangement of these air-holes the position of the larva in water largely depends. Thus, the anopheline larva lies almost horizontally beneath the surface of water, whereas the larva of other varieties hangs head downwards, the point of the air-tube only touching the surface (Fig. 2). In about twelve days the larva is fully grown, and becomes a nymph, which shows curious jerky movements, remains in the water, and partakes of no food. In shape the nymph is not unlike a tadpole, having small breathing tubes above the thorax. After three or four days the perfect insect hatches out and flies away.

The situation, therefore, in regard to the causation of malaria amounts to this, that the disease does not occur spontaneously without the presence of anopheline mosquitoes, the existence or recent presence of cases of malaria from which the mosquitoes may derive the infection, and climatic conditions favouring the activity and susceptibility of the mosquito for the full development of the malarial parasite. In the absence of any one of these factors an outbreak of malaria is impossible. The preventive measures against malaria are partly personal and partly public. Personal measures will consist, in the first place, of precautions to avoid being bitten by infected mosquitoes. This entails the careful use of mosquito-curtains at night, the provision of wire-gauze screens to all doors and windows, coupled with the wearing of veils over the helmet and head, and of gloves or mittens on the hand when exposing oneself at night in places where infected mosquitoes exist or

are suspected to exist. Obviously these measures are of limited applicability to the general circumstances of soldiers, but are capable of being adopted, and should be adopted when feasible. Periodical and frequent fumigation of rooms with formalin or sulphur will do much to kill adult mosquitoes and drive them away from dwelling-places. In the case of soldiers' barracks this practice should be followed weekly in malarial countries. So, also, ought the rafters and roofs and ceilings of barrack-rooms to be more frequently dusted and brushed out; these are places of gloom and quiet for which the mosquito has a predilection, and a little more care and interest displayed by squadron, battery, and company officers as to the systematic cleaning of barrack-rooms would be productive of a lessened incidence of malaria in many tropical garrisons. The same principles should be applied to married quarters and other places hung with curtains and draperies, which all harbour dust, flies, and mosquitoes. To these precautions must be added care to live at a distance from infected people, such as native children and others, supplemented by the taking of quinine for the destruction of malarial germs or parasites which may have gained an entrance into the blood.

The public prophylaxis of malaria, though theoretically identical for every place, is in practice rarely feasible in its entirety for all localities. Where possible, the detection, isolation, and cinchonisation of the infected is of the first importance. In military life this is almost impracticable, except in regard to detection and cinchonisation. More might be done towards providing mechanical protection in barrack-rooms from

mosquito bites; the personal prejudices of the individual soldier are, however, a serious difficulty against its development and enforcement. The chief line of action in the direction of administrative prevention of malaria must be towards the reduction of mosquitoes, and the only chance of success lies in an organised and systematic attempt to prevent their breeding. Mosquitoes breed only on shallow, stagnant water; hence every effort must be made to prevent the formation of rain-water pools and the accumulation of water in drains, gutters, tubs, and other vessels in the vicinity of barracks or houses. These must be seen to daily, all collections of water being brushed out and removed. On similar lines, larger pools, ponds, or marshes should be drained. If this is impracticable much benefit results from oiling these waters, by pouring kerosene oil on to them in the proportion of one pint to each 400 square feet. This produces a fine surface film or scum, and acts beneficially by killing eggs and larvæ of mosquitoes which may be hatching on the surface of such water. Complete suppression of mosquitoes is probably impossible, but anti-malaria campaigns organised on these lines to minimise the breeding of mosquitoes have been productive of great good in many places; so much so that the persistence of much malaria in tropical garrisons can only be looked upon as proof of sanitary maladministration. It is to be hoped that regimental officers will display more initiative in regard to these matters in their own lines in tropical garrisons than they have done in the past. Consistent and steady application of measures to reduce the numbers of mosquitoes in barracks would soon be rewarded by a sensible

diminution in the number of malaria cases among the men, the co-operation of whom might well be fostered by a simple explanation of the reasons.

Enteric Fever, or typhoid fever, has ever been the scourge of armies, especially during war, in camps or other places where sanitary precautions have been neglected. It is also common in peace-time, both in civil and garrison life, among all civilised races. In Great Britain, among the civil population of all ages, this disease prevails to the extent of 8 cases in each 10,000 persons; between the ages of ten and thirty it prevails to the extent of 13 cases in each 10,000 inhabitants. Among armies during peace we find for each 10,000 men serving 156 cases in the British army in India, 141 in the French army, 38 in the Russian, 36 in the United States army, 16 in the Austro-Hungarian, 9 in the German, and 6 in the British army at home. Of individual British garrisons, South Africa shows the greatest number of cases after India, the ratio per 10,000 of strength being 93; Ceylon has 80; Egypt, Mauritius, and Bermuda have 75; Gibraltar has 30, Crete 24, Malta 21, and other places smaller numbers varying from 15 to 5. The youth and short service of those attacked is the distinguishing feature of all enteric outbreaks, but which is the dominant influence we do not know. As about one case in five ends fatally, it is obvious that, with the above indicated prevalence of enteric fever, there results a considerable number of deaths from the disease annually in the various commands. It must be remembered that different outbreaks vary considerably in their virulence, but, taking the average of the last ten years, the annual

number of deaths from enteric fever per 10,000 of strength has been 53 in India, 30 in South Africa, 51 in Egypt, 67 in Crete, 50 in Mauritius, 17 in Malta, 9 in Gibraltar, and 2 in the United Kingdom.

Enteric fever is caused by a germ which reaches man in a variety of ways, notably by water, by milk, food, such as oysters and shell-fish, watercress, and by means of dust-laden air. The disease declares itself in from eight to twenty-one days after the germ has gained access to the body, and comes on, as a rule, gradually. It shows itself by continued fever, great weakness, and frequently by diarrhœa. Ulceration of the bowels is its distinguishing feature. It lasts from three to five weeks, and relapses are not uncommon; one attack does not protect absolutely from another. The infected person gives off large numbers of the enteric germs by means of the urine, the excreta, and the expectoration from the lungs and air-passages, not only during the whole course of the disease, but in many cases for some weeks after convalescence and recovery. One of the greatest difficulties connected with this disease arises from the fact that many mild attacks occur—so mild, indeed, that the persons do not feel ill enough to report sick, or, if they do feel ill, the sickness is of such a passing nature that a few days' rest causes or favours a feeling of complete good health. Cases of this kind are very common among soldiers, and are extremely difficult to detect; yet all the time they are potent factors for evil, as the individual is distributing enteric germs broadcast. Apart from this class of mild cases, it is well known that persons who are apparently quite well may be bearers of enteric bacilli and be passing

urine and excreta full of the infective germs. These persons are individuals who either have been in recent contact with the enteric sick or have had the disease and recovered from it.

The most common source of enteric infection is probably water which has been fouled by sewage. After this may be placed infection attaching to blankets, bedding, and clothing. Among soldiers this is much more common than many suppose, owing to the want of care taken to prevent blankets being issued indiscriminately —that is, to safeguard the blankets of a man in hospital being issued to some other man. Considering the numbers of soldiers who wet their bedding at night, the possibilities of infection by blankets are readily understood. Another common source of infection is by germ-tainted food. This may arise in warm countries through the agency of flies, who pass constantly from garbage and other filth to food; also by means of enteric-tainted dust blown on to food; while similar mischief can arise from the presence among cooks, waiters, and others of a man who is the unconscious subject of the disease or the carrier of its germs. Uncooked vegetables, such as lettuce, watercress, &c., which has been watered or washed with water containing excreta, frequently cause the disease. The same is the case with oysters and other shell-fish kept in contaminated water or fished from beds where the water is polluted with sewage.

This summary of the ordinary channels of infection will at once suggest lines of defence. No food or drink whose history is unknown should be taken without being first cooked, or sufficiently heated to destroy any

germs. Food stored should be adequately protected from flies and dust. Milk in particular needs to be safeguarded, as it is a suitable medium in which germs will develop. Milk drawn from water-buffaloes in India and elsewhere should invariably be boiled before issue; these milch cows are often driven straight from ponds or tanks to be milked, with their udders dripping with foul water. Raw vegetables and shell-fish need to be scrupulously washed in safe water before consumption. Supplementary to these precautions are measures taken not only to dispose safely of all excreta, but also to keep the latrines and closets sweet and clean, more especially where the dry earth system is in vogue, to ensure prompt and adequate protection from the fly. Valuable as these precautions are, they will be futile unless the personal cleanliness of the soldier is rigidly supervised and enforced. This involves not only cleanliness of the man, but also of his clothing and bedding. In camp and at other times when men are crowded together infection by bedding or clothing is very common. To these preventive measnres may be added the encouragement of inoculation against enteric fever.

Dysentery.—The early history of our army affords constant references to this disease. It is probable that under the name of dysentery may have been included many cases of what is recognised as enteric fever in the present day. Still, even so, we find the disease very prevalent in our own times. There are two forms of dysentery, the one due to a small germ closely related to that of enteric fever, and the other to an amœba. The symptoms of these two forms are indistinguishable

from one another, but the former type of infection is the more common, especially among soldiers in the field.

The onset of this disease is sudden, as a rule, the symptoms being pain in the bowels, a constant desire to go to stool, severe straining, and the passing of slime and blood, with, later on, some shreddy matter. It is, in fact, an inflammation and ulceration of the large intestine. In favourable cases it remains acute for about a week, but it may drag on for longer. The disease is probably a local affection, and one attack does not protect from another; relapses are frequent. The germs or infective matter are passed out of the body in the fæces, and possibly also by the saliva. The various channels and sources of infection are similar to those described under enteric fever, but it differs from that disease in this respect, that chills and exposure to damp and wet exercise a distinct predisposing influence. Blankets and clothing used by the infected are very liable to convey the germs to others who may use them; while, certainly, flies are potent carriers of infection to food. The special preventive measures for dysentery are practically the same as in the case of enteric fever, namely, care in the disposal of excreta, protection of food and water from contamination, personal cleanliness, and the early detection and segregation of the infected sick.

Infective Diarrhœa.—The frequent movement of the bowels and consequent evacuation of excretal matter is constantly spoken of as diarrhœa; strictly speaking, the term diarrhœa implies merely a symptom, and in the majority of cases is but the involuntary

attempt of the bowels to dislodge some indigestible or irritating material which has passed into the digestive tract. The phenomenon of diarrhœa is a common symptom at the commencement of several diseases, notably enteric fever, dysentery, and cholera, and for this reason is of great importance as a danger-signal during epidemics of these diseases, suggestive of the desirability of men so indisposed reporting sick at once. Apart from simple looseness or irritative diarrhœa, which is a common affection among troops in the field, there is a special form of the complaint known as infective or epidemic diarrhœa. This is caused by an infecting germ, and, if not controlled early and regarded as an infective disease, may develop into an extensive outbreak, with consequent loss of efficiency. Flies, dust, and uncleanly habits on the part of the individual are probably the chief influences producing this disease among troops, the vehicles of infection being usually impure water and sewage-tainted food. The measures to be taken for its prevention are similar to those required in the case of enteric fever and dysentery.

Cholera.—Formerly this was a very common disease among British troops in India. In the present day, owing to the greater care taken as to water supplies, it is rare, the majority of outbreaks being confined to native soldiers. The endemic home of this disease is India, where it constantly prevails among the civilian native population. No country is safe from it, occasional epidemics having occurred in this country and other parts of Europe. Once the infection is imported, no insanitary community is safe from an epidemic of cholera.

The incubation period of cholera is from two to five days. The disease generally comes on suddenly, but it may begin with a slight diarrhœa. There is violent purging and vomiting of material resembling water in which rice has been boiled. The patient suffers from severe cramps all over the body, the face is pinched and grey, and the whole body gets very cold. Death frequently occurs in a few hours, while in favourable cases the recovery is often equally rapid. The disease is caused by a minute germ shaped like a printer's comma, which is taken into the body by the mouth, usually in water, but also in milk or by other food contaminated with the infecting germ. The cholera germ not only lives but multiplies in water, especially if the water is stagnant and dirty. It is rapidly killed by acids, by exposure to the sun and drying. The most common channel of infection is water, and by means of articles of bedding and clothing which have been soiled with the discharges from the sick. The germs are given off in large numbers both by the bowel discharges and the vomit. Careless handling of these has been the cause of many instances of infection. The habit of the natives of India of frequenting tanks and river-banks in order to obtain water for washing their person after going to stool is responsible for the contamination of water with cholera germs, and the consequent dissemination of the disease. The germ may also pass directly into food through careless handling of plates and dishes by native servants with unwashed hands. In Indian and other communities in which safe water supplies have been installed and protected from such methods of

contamination the disease has been practically stamped out.

Men who suffer from indigestion, or worry about and fear this disease are remarkably liable to contract cholera in epidemic times. This is probably due to some loss of their normal ability to destroy the infecting germs by means of the healthy digestive juices. This circumstance suggests the need of avoiding indigestible foods, excess of alcohol, uncooked vegetables, unripe or over-ripe fruit, and anything likely to upset the stomach. Whether exposure to chill is a predisposing cause to infection is doubtful, but the rule should be to avoid chills, more particularly of the abdomen. The essential protective measures are the safeguarding of water and food from any possible contamination, the strict guarding against the careless deposit of excreta, the enforcement of rigid personal cleanliness, especially of the hands, and the early recognition and separation of the sick. There is nothing mysterious about cholera; it is an infectious disease the direct outcome of filth and filthy habits, and preventable only by a due recognition of this fact.

Typhus Fever.—This is not the same disease as typhoid or enteric fever. Formerly it was very common in armies, chiefly owing to overcrowding, faulty feeding, and general squalor and uncleanliness. We never see it in the British army at the present time, but it is still a disease affecting troops in South-Eastern Europe, and in large cities both at home and abroad. It is especially a disease among the very poor and in crowded and dirty populations, and for this reason is liable to attack soldiers in a besieged place, or wherever

the surroundings are insanitary and the quarters overcrowded. The particular germ of the disease has not been discovered, but that it is caused by a germ is certain, as typhus is both contagious and infectious. The prevalent idea is that the disease is communicated by the breath of patients or by articles in contact with them, such as bedding or clothing. Our own view is that the vehicle for transferring the infective germ from one person to another is the ordinary flea. The preventive measures against typhus are essentially cleanliness of the person, of the clothes, and of the home or dwelling, coupled with free access of fresh air and removal of overcrowding.

Plague.—Fortunately this disease has not become prevalent among soldiers in our army, although it prevails to a deplorable extent among the native population of India. In the Middle Ages it devastated many countries and many armies. Plague is an infectious, communicable disease characterised by high fever and painful swellings of the glands, generally in the groin or armpit, called buboes. A very fatal form of plague is marked by severe pneumonia without swelling of the glands. The incubation period of the disease lasts about five days. The cause of plague is a special bacillus or germ. The disease is primarily a disease of rats, and only passes to man as a secondary epidemic. The transference of the infection from the rat to man, and also from rat to rat, is by means of the flea of the rat. The evidence in support of this view is overwhelming; so much so that we may say that where there are no rats there will be no plague. This circumstance explains the curious immunity of the white races from the

disease in India, and its excessive incidence among the natives, whose homes are notoriously overrun with rats. The majority of cases which have occurred among white troops have been in men who have either been detailed or have volunteered for plague duty in bazaars, or have been in the habit of sleeping with native women; in both classes the white man has been in close relation with the native dwelling and the rat which frequents that dwelling. These facts indicate that the practical precautions to be taken to prevent the occurrence of plague among soldiers are the avoidance of native houses and quarters, coupled with the extermination of rats. Complementary to these measures are the avoidance of overcrowding, maintenance of buildings and barracks in such repair that they will not harbour rats, and the inspection and supervision of native servants, cook-boys, and others frequenting the lines.

Malta Fever.—Sometimes called Mediterranean fever, this disease has prevailed much in Malta, Gibraltar, Crete, India, China, and South Africa. Up to the middle of 1906 the garrison of Malta lost annually the services of 650 soldiers for a period of 120 days each, making a total of some 80,000 days of illness, and as it was found necessary to invalid most of these men to England the loss to the State was considerable. The incidence of the disease among officers in Malta was even greater than among the men—so much so that it reached the alarming ratio of 131 per 1000. For this reason Malta has long been looked on as one of the most unhealthy and dangerous of foreign stations. Malta fever shows itself by successive attacks of continuous fever, each attack lasting for three weeks or a

month, and even longer in some cases. There is also pain in the joints resembling rheumatism. Few cases end fatally, but there is so much debility that the services of the patient are lost for considerable periods. The incubation period of the disease varies from one to three weeks. One attack will protect from further attacks. The cause of the disease is a small germ, which is usually swallowed in goat's milk. Once infected, the patient passes large numbers of the infective germs out of the body by means of the urine and fæces. It is now known that goats suffer from this fever, and as goat's milk is the chief milk-supply of countries on the Mediterranean coast this fact is suggestive of the origin of the disease. Since July 1906 goat's milk has not been allowed to be issued to troops in Malta, and the cases of Malta fever have practically dropped to one-twelfth of what they were formerly in that garrison. If these good results continue there is every reason to hope that the disease will disappear altogether; in any case, the essential preventive measure is the avoidance of goat's milk, or the insistence upon boiling it before use.

Tuberculosis.—In the past, as the result of consumption of the lungs, a very high invaliding and death-rate prevailed in the Army. At the present time tuberculosis is not very prevalent among soldiers. Expressed as ratios per 10,000 men, the following number of cases occur: In the United Kingdom, 29; Gibraltar, 31; Bermuda, 53; Ceylon, 27; Straits Settlements, 37; India, 18; South Africa, 16; Egypt, 14; and Malta, 11. Tuberculosis is essentially an infectious disease, being caused by a germ which

attacks various parts of the body, but more commonly the lungs and joints in adults and the bowels and coverings of the brain in children. The infection is slow, causing the disease to run commonly a protracted course, and ending usually fatally if the lungs are the seat of disease. The chief channels of infection are the air and milk. Inhalation of tubercle germs is probably more common in adult life; hence the greater prevalence of phthisis or pulmonary consumption among grown-up persons than among children. On the other hand, the excessive prevalence of tuberculosis among cows, and the corresponding tainting of some 10 per cent. of milk samples with tubercle germs, causes this food to be a fruitful source of infection during young life. In the case of the soldier milk as a source of tubercular disease probably plays no part. The same may be said of tuberculosed meat. The present-day reduced incidence of tuberculosis in the Army is attributable partly to the great attention now paid in barracks to good ventilation and a sufficiency of both cubic and floor space to each man, but perhaps in even greater measure to the care taken to discover and segregate early cases of tuberculosis of the lungs, and the prompt invaliding out of the Army of men so affected whose condition has become chronic and without hope of early arrest and cure. This policy reduces to a minimum the opportunities afforded for the spread of tubercular infection among soldiers. Its practical efficacy can only be secured by the co-operation of regimental officers in avoiding overcrowding in barrack-rooms and the maintenance of cleanly habits among the men, notably the strict suppression of spitting.

Yellow Fever.—In the present day this disease rarely occurs in our army, but formerly it devastated many of our garrisons in the West Indies, Bermuda, and the West Coast of Africa. It is essentially a disease of the West Indies and of Central and Southern America. It is now known that yellow fever is not a filth disease, but one caused by a very minute germ, which gains access to and exists in the blood of the infected person. This germ passes from one person to another by the agency of a certain species of mosquito, known as the *Stegomyia fasciata*. The history of the germ in this mosquito is probably analogous to that of the malarial germ in the *Anopheles* mosquito. We have reason to believe that the mosquito can only obtain the germ from man's blood during the first three days of infection; hence it is of great importance to prevent an infected person being bitten by this mosquito during the earlier days of the illness. The yellow fever mosquito has often been brought over to Europe in the cargoes of ships, but, owing to the climate, it dies off quickly. This fact explains why, in spite of frequent importations of yellow fever, the disease has never spread in European countries. This mosquito selects especially house water-tanks for depositing its eggs, and, amongst preventive measures, the covering of these tanks and their inlets with mosquito-proof gauze is important. Other measures are the destruction of mosquitoes in all buildings where yellow fever occurs, and the protection of both patients and healthy persons from being bitten by them. Measures on these lines and similar to those advocated against malaria have been so successful in Havana and elsewhere as to

abolish practically the disease from places which previously had never been free from it.

Scurvy.—This is not a communicable disease, but it has been the cause of an immense amount of sickness and inefficiency in all armies. It is especially liable to occur in besieged garrisons and on board ship, under circumstances where fresh food cannot be obtained. We get a few cases still in our army, especially when there is an absence of issues of fresh meat and fresh vegetables. The early symptoms are pains in the calves of the legs and anæmia; later the gums become swollen, and marks like bruises appear on the body. Complications such as diarrhœa, dropsy, and heart-failure may occur, causing death in severe cases. Scurvy may be prevented by the issue of fresh meat, fresh vegetables, and fruit. When these cannot be obtained, or are obtainable only in insufficient quantities, a daily issue of an ounce of lime-juice is an efficient substitute. On this account lime-juice is an important item in the soldier's ration on board ship and in the field.

Cardiac Affections.—Under this head we place a number of diseased conditions of the heart and circulatory system which are notoriously common among young soldiers. This question will be referred to again when considering the physical training of the soldier. These affections are not communicable, but essentially the outcome of faulty methods of drill, physical training, and possibly also of dieting. As illustrative of the extent to which this disability prevails among soldiers the following figures are instructive. Among each 10,000 men serving in the Austro-Hungarian army there occur 19 cases; in the Russian, 24; in the

French, 26; in the German, 35; in the United States army, 38; and in our own, 73. Of these quite one-third are lost to the service by invaliding. The disparity between these ratios is certainly suggestive, and indicates that the matter is of more than academic interest. There is every reason to believe that the excessive incidence of these cases is to a large extent preventable by a more rational method of physical training, and by the inculcation into the soldier himself of the simple fact that it is impossible to train if one smokes and drinks.

CHAPTER IV

THE PRINCIPLES OF DISEASE PREVENTION

EFFECTIVE measures for the prevention of disease can only be devised and practised when the causes and nature of individual diseases are understood, and when the method by which they invade the body is known. In the last two chapters an attempt has been made to render these essential facts clear, more especially as regards the communicable diseases. It has been pointed out that all communicable diseases are due to the invasion of the body by germs, each disease being caused by a germ special to itself. This, however, is not the whole story, and we have to take cognisance not only of the cause itself, but also of predisposing conditions. Under this last category may be classed anything which lowers the power of resistance to disease or that renders the individual more susceptible to its influence, such as age, fatigue, mental depression, exposure to great heat or cold, sudden changes in temperature, recent arrival in a hot climate, insufficient or improper food and clothing, dissipation or alcoholic excess, overcrowding in barracks, insanitary surroundings, and careless or dirty habits. In other words, we must have not only the germ or seed of disease, but the body or soil must be favourable for

its reception. On this conception of disease causation, the principles of disease prevention divide themselves into two main headings: (1) Measures to maintain the resistant powers of the individual; (2) measures to prevent or minimise the possibilities of disease germs entering the body. Among the former measures a prominent place must be given to protective inoculations, while among the latter measures are such matters as personal cleanliness, clean air, clean water, clean food, and a variety of details which are best considered in respect of the special circumstances of the soldier's life.

Protective Inoculation. — Mention has been made of the fact that in the case of the majority of the communicable or preventable diseases infection does not occur commonly a second time, notable examples in which this is the case being enteric fever and small-pox. This being so, the question suggests itself, why should not men be given or put in the way of acquiring a mild form of disease such as these, so that future infection of a severer nature may be rendered improbable, if not impossible? In the case of small-pox the inoculation of people with the disease was practised formerly, in the hope of giving them a mild form of the infection, and so preventing the occurrence of severe cases. Owing to faulty methods of inoculation, severe cases did occur, and the disease got so much out of hand that the practice of inoculation with small-pox had to be forbidden. Its place is now taken by the modern procedure of vaccination. This is really nothing but the inoculation or infecting of human beings with the germs of small-pox after it has been through the cow

or calf. In other words, the cow or calf is infected with human small-pox. This does not make the animal ill; all that follows is the appearance of some blisters and sores on the animal, which yield a juice or lymph which, if inoculated (vaccination) into man, confers on him an ability to resist infection by the human small-pox. A very similar train of events occurs in the case of diphtheria in the horse. If inoculated with diphtheria germs, the animal does not get ill, but manufactures in its blood an antidote (anti-toxin) to the diphtheria germs and their poison. If the animal be bled judiciously, its blood yields a watery fluid, rich in anti-toxin, which, if injected into man, exercises both a preventive and curative influence on him against the human disease. The same idea is present in the attempts to ward off infection by enteric fever by injecting the killed germs into man, causing thereby the infected person to manufacture sufficient anti-toxin to enable him to resist infection by natural means. The procedure is constantly being carried out in the Army, but, unfortunately, the protection against enteric infection which it gives is not as lasting or as complete as was hoped it would be. As a matter of fact, the protection probably lasts only some two years; but, even so, it is something worth having, especially if it covers or tides a young soldier over a critical or dangerous period, when his powers of resistance to the disease are likely to be at their lowest and the chances of infection are likely to be at their highest.

It may be asked, admitting the scientific accuracy of the premisses upon which the whole argument in support of protective inoculation is based, what is the

statistical evidence in favour of the practice so far as relates to enteric fever in the Army? This evidence covers a period of ten years. The earlier records are to a large extent valueless, owing to the imperfect organisation available for the collection of exact data, and the difficulties experienced in tracing the after-histories of men who had been inoculated. Confining our attention to recent years, during which every endeavour has been made to render the data reliable, the following facts are of interest. During the period from March 1, 1906, to February 28, 1907, there were 1963 men inoculated in the United Kingdom; among these there occurred no cases of enteric fever within the year, while there were 56 cases, with 7 deaths, among those not inoculated, the respective ratios per 10,000 of strength being *nil* and 6·3. During the same period 2130 men were inoculated in India; among these there occurred 8 cases, with 1 death, while among those not inoculated there were 770 cases, with 101 deaths. The respective ratios of cases in these two groups per 10,000 of strength, worked out at 37·5 and 203·2. At other garrisons abroad in the same period 791 men were inoculated; these gave 5 cases, with no deaths, while there were 193 cases, with 20 deaths, among those not inoculated. Expressed as a ratio per 10,000 of strength, the respective figures are 63 and 62. Taking the figures for the whole Army serving at home and abroad, we find per 10,000 of strength a ratio of 26·6 among the inoculated and one of 61·8 among the non-inoculated; the percentage mortality to attack in the two groups of men works out at 7·7 and 12·6. These figures show that in the three

divisions, as a whole, into which the Army has been divided the admission rates for enteric fever are greatly in excess among the uninoculated, while the mortality rates also compare more favourably for the inoculated. In the case of stations abroad other than India, where the difference in the incidence of the disease is in favour of the uninoculated, it may be stated that all the five cases among the inoculated occurred in South Africa. Further, in view of the limited period of protection claimed by the advocates of anti-enteric inoculation, it is of interest to state that of the thirteen cases of the disease shown above as occurring among the inoculated, seven contracted it at an interval of over three years after inoculation, while in the one case of death the intervening period between inoculation and attack extended to nearly eight years.*

The following figures are available in regard to the effects of inoculation among men of the 17th Lancers. This regiment left England in 1905 for India, and within a few weeks after its arrival enteric fever broke out in it. The results obtained by anti-enteric inoculation can be held to constitute a test-case, as they were checked by examinations of the blood and by necropsies. Of 514 persons in the regiment, 127 submitted to a complete inoculation against enteric by means of two injections, 23 received only one injection, and 364 refused to be inoculated at all. Up to the end of the first year no cases of enteric fever occurred amongst the 127 fully inoculated, 2 cases occurred among the 23 partially protected, and

* See *Journal of the Royal Army Medical Corps*, December 1907, ix. 613.

61 cases occurred among those who refused to be inoculated.* Equally striking results were obtained in the 3rd Coldstream Guards, who embarked for Egypt in September 1906. There were 331 inoculated and 381 non-inoculated persons in the battalion. During the first year one case of enteric fever occurred among the inoculated and thirteen among those who had not been inoculated, or a percentage incidence of the disease of 0·3 in the one group and 3·4 in the other. It would be difficult to find a more striking series of figures.† The results of similar inoculations among German troops in South-West Africa show a death-rate of 4 per cent. from enteric fever among the inoculated, as against 11 per cent. among the uninoculated. All reports indicate that those who have been inoculated against enteric fever, even though they may not acquire complete and lasting immunity against infection, have a decided advantage over the non-inoculated should they contract the disease; and this is in proportion to the number of times they have been inoculated. The toxin effects are diminished considerably, the complications are less frequent, relapses are fewer, and the case-mortality is reduced to less than half, almost to one-third.

Other Means of Protection.—It must be admitted that our ability to prevent or ward off infection from diseases of an infective nature by means of preventive inoculations is still small, and limited to only one or two diseases, notably small-pox and diphtheria; still, it is founded on scientific facts, and, as our know-

* *Journal of the Royal Army Medical Corps*, May 1907, viii. 492.

† See *ibid.*, April 1908, p. 429.

ledge becomes greater, will extend. For the present we are bound to recognise it as a possible means of great value, and to regard sympathetically all efforts to extend its scope and application. Failing, then, a complete scheme of protection against infective diseases by means of preventive inoculations of their causative germs, on what must we depend? Obviously, on a rational and wholesome mode of life, clean air, clean water, clean food, and cleanly surroundings as attainable by a proper removal of filth and waste materials, combined with the organised control and management of the infected, and the disinfection of their infected clothing, products, and surroundings. The importance of these matters cannot be too forcibly impressed upon the soldier, more especially the subject of personal cleanliness.

Personal Cleanliness.—Under this heading the soldier needs to be instructed that personal cleanliness involves not only attention to the skin, but to the hair, nails, teeth, mouth, and other parts of the body. The skin is a covering for protection, and for getting rid of water in the form of sweat. This latter function is increased by exercise, as well as by other causes. If sweat be allowed to continually remain and dry on the surface of the skin, or soak into the clothing, it soon becomes irritating, unhealthy, and offensive. For these reasons we wash our bodies to remove not only coarse dirt which we can see, but also the dried sweat which we cannot see. The act of washing, further, improves the skin, opens and cleans its pores, and keeps it sweet and healthy. Most persons wash their hands and faces, but often forget parts covered by clothes.

Of these, the following should be washed every day when possible: (1) Between the legs and buttocks; (2) the armpits; (3) the feet and toes. In addition to this daily washing, a bath once or twice a week is necessary, but baths should not be taken within two hours of eating a meal. After bathing or washing the skin should be well rubbed, so as to improve the circulation of the blood. Hands should be washed before eating, and when washing the hands care should be taken to trim and clean the nails. It is an important and simple matter to keep the nails clean and in good order. The finger-nails should be cut round and the toe-nails straight across. Dirty nails and fingers are a common means of conveying infection.

The hair must be kept closely cut, be brushed and combed daily, and frequently washed. Pomades and grease are, as a rule, unnecessary. The mouth should be kept scrupulously clean, and the teeth cleaned at least once, if possible twice, a day by rubbing with a brush. The best time to use the tooth-brush is before going to bed, so as to remove particles of food after the evening meal. The mouth should be washed out with water both morning and evening. Decaying or painful teeth ought to be reported to the medical officer. Often the gums are soft and inclined to bleed; because this is the case one must not cease to clean the teeth. At first the tooth-brush may cause a little inconvenience, but continued use will harden the gums.

Closely connected with the care of the skin is clean clothing. Dirt from the clothes reaches the skin, and dirt and sweat from the skin soak into the clothing. For these reasons it is important to change and wash

underclothing. The same clothes should not be worn by day and night. With a little management every man should be able to keep a shirt and pair of drawers for night wear. Socks get dirty very quickly. Men should be encouraged to try and have two pairs in use, one for the morning and one for evening wear. There should be also two pairs for the wash. Unless care be taken in attention to details of this kind it is impossible to keep the feet hard and clean. Underclothes as well as overclothes can be cleaned by brushing, shaking, and exposing to the sun and air. This is nearly always possible even when washing cannot be managed, as, for instance, in camp or on the line of march. An article of kit which is often neglected is the hair-brush. Men should be made to wash it every three weeks or so. They should be instructed not to use soap or hot water, but to rinse it in a basin of cold water, to which has been added a teaspoonful of washing soda; this will remove all dirt and grease. Dry it by shaking or swinging it round, and place it to dry in the sun or wind.

The foregoing principles and rules may appear unnecessary to the officer, but they are matters which every officer should impress upon all young soldiers coming within his range of command.* The various questions involved in the attainment of clean air, clean food, and clean water can be more conveniently discussed in subsequent chapters, dealing with the barrack and water supplies.

Isolation and Disinfection.—There remains one other procedure to be borne in mind in connection with the control and prevention of infectious disease; this is

* "King's Regulations," 1908, para. 112.

the proper segregation of the infected or those who have been in contact with the sick from the healthy, coupled with efficient disinfection of discharges from and of clothing or bedding used by the infected. To a large extent these are matters of executive by the medical corps, but a right comprehension of their importance and necessity is incumbent upon every one. Except in the case of a few diseases of an acutely virulent type, such as small-pox, plague, and typhus fever, active segregation of contacts is rarely called for in Army life, but a recognition of its advisability when demanded by the medical service must be remembered as an important aid in checking the spread of infection, especially among the susceptible. Segregation is efficient if extended over a period corresponding to the ordinary incubation stage of the disease suspected, during which time, if infection has taken place, the symptoms will have declared themselves. The incubation periods of the more common infective diseases are the following: Small-pox, 12 days; scarlet fever, 6 days; measles, 18 days; diphtheria, 8 days; enteric fever, 14 days; typhus fever, 12 days; plague, 10 days; and cholera, 3 days.

Disinfection means the application of some procedure to kill or destroy actual germs of disease. The mere removal of a smell or the delaying of the growth of bacteria is not disinfection. The actual practice of disinfection is essentially a matter for the medical corps, who are furnished with efficient means for its conduction. Except in the case of places which have been occupied for some time by those suffering from small-pox, scarlet fever, and tuberculosis of the lungs, it is

rarely necessary to disinfect a room simply because a case of infectious disease has occurred among its occupants. The reason for this is the fact that the germs or causative agents of the majority of the infectious diseases attach themselves to the persons, bedding, or clothing of the infected, and not to the walls, ceilings, fittings, and floors of their rooms. In the majority of cases these latter can be rendered sanitarily safe by the exercise of free ventilation, admission of light, and scrubbing with soap and water. It is otherwise with bedding and clothing; these need to be handed over to the medical corps for disinfection by either steam or such other procedures as technical knowledge deems to be necessary. But, as mentioned elsewhere, co-operation and care must be exercised that all such suspected bedding and clothing are properly detached from articles of a similar kind, duly marked with a tally, and handed over to the medical corps for disinfection. Failure to attend to details of this nature is merely trifling with disease and its prevention.

CHAPTER V

ORGANISATION OF SANITARY EFFORT

In the preceding chapters an attempt has been made to explain not only the extent to which disease prevails in the Army, but also what are its actual causes and the principles on which prevention must be attempted. We need now to consider what are the agencies by which organised sanitary effort in the Army is to be carried out.

It is obvious that the successful working of any measures for the prevention of disease depends entirely on the fullest co-operation of every individual in the Army. This conception of organised sanitary effort is the fundamental idea of any scheme of sanitation, and cannot be too strongly impressed upon every one. It is impossible to expect the health of an army to be maintained by any single body of men, however numerous, without the support of the whole community, and it is this popular support and appreciation that have placed the public health service of Great Britain in the very prominent position which it at present occupies. This fact unfortunately has not been appreciated in the Army, with the result that an idea has prevailed that sanitation or the prevention of disease was exclusively a matter for

the medical corps. Such a view is absolutely wrong, and cannot be combated too strenuously. The medical corps, by virtue of their technical training, are and must be the teachers or guides of others in the principles and practice of sanitation, but, alone and unsupported, any efforts on their part must necessarily be futile. We see this in so simple a matter as the storage and issue of blankets or bedding. The medical service, finding that a certain individual is suffering from an infectious disease, applies to the man's unit for his blankets or bedding to be sent up for disinfection. Whether the right articles are sent or not depends absolutely upon the sanitary discipline of the unit. Too often the articles have been placed in the company store, and, hopelessly mixed up with others of a similar kind, are untraceable as having been used by any particular individual, or they have been re-issued to some one else. All the same, bedding or blankets are sent up for disinfection; but they are not necessarily the infected articles: these are either infecting other articles in the store or are infecting their new possessor. This is no overdrawn picture, but illustrates clearly the futility of isolated effort on the part of any one individual or group of individuals to control the spread of infection. What is the use, in this case, of the medical service going to the trouble of disinfecting blankets or bedding which have never been used by the infected man, while the actually infected articles escape? Clearly, no use; and the failure is due to defective sanitary effort in the unit itself. Instances of this kind will gradually become rare as knowledge of the principles and prac-

tice of sanitation becomes more fully spread through all ranks.

Admitting, then, that sanitary effort means co-operation of all individuals in the Army, its successful application is merely a question of education and the recognition and organisation of a *personnel* to give it effect. The former can only be gradual, but is being developed by the various addresses or lectures given by medical officers in the different commands to officers and men, as well as by the work of instruction carried out in the School of Army Sanitation at Aldershot. The *personnel* of the sanitary service is to be found in the regimental sanitary squad of one non-commissioned officer and six men per regiment of cavalry or brigade of artillery, and one non-commissioned officer and one man per company of all other units, working under their own regimental officers, instructed and supervised by medical officers in charge of units or brigades, or by specially detailed sanitary officers of the medical corps.* The conditions of ordinary duty in garrisons in peace-time do not call for any marked activity of this regimental sanitary *personnel*, but their presence and utilisation during marches, camps, field training, and manœuvres is essential for their proper employment in time of war, when their efficiency must have a notable influence on the sanitary condition of the force to which they belong. There is some danger of these regimental sanitary sections being lost sight of or imperfectly used in peace-time, and too great a stress laid on their being mere "war establishments." This must not be, for the maintenance of sanitation on field service means co-

* See Army Order 3 of 1908, also "War Establishments," 1907–8.

operation of all troops, and the application of such knowledge of hygiene and training in sanitary methods as are acquired during peace.

In time of war the scheme of sanitation for field service involves a series of measures required (1) in the field army, and (2) those appropriate to the lines of communication and at the base. Each set of circumstances presents difficulties peculiar to itself, but both involve the attainment of (*a*) a safe water-supply; (*b*) the rapid and safe disposal of all waste products of men and animals, the destruction of refuse; and (*c*) the early segregation of those affected with infectious or contagious diseases.

In the *field army* sanitary measures must be of the simplest nature, and under the control of the commanding officers of units, who alone are responsible for the health of their units. The officer commanding a unit will have at his disposal for sanitary work the following establishment, namely, an officer of the medical corps, a sanitary squad, and a water squad. Though primarily intended for the technical care and treatment of the sick or wounded, the medical officer attached to a unit is meant to devise, recommend, and if necessary aid in executing such measures as may be suited to the various health problems arising in war and affecting the men in his charge. In this sense the first group of duties of the medical officer are executive, while the second group are more or less advisory. The sanitary squad, the members of which are obtained from the establishment of the unit itself, are the same as mentioned above under peace conditions. These men will have received a course of instruction in elementary

sanitary methods during times of peace, and be employed not only as sanitary police generally, but more particularly in the sanitation of camps and the supervision of excreta and refuse disposal. The water squad attached to the unit will be composed of men drawn from the Royal Army Medical Corps, specially trained in the use and care of various equipments for purification of water. Detailed mainly for duty in the care of water-carts, filters, sterilisers, and the provision of safe water for the unit, these men will also be available in connection with disinfection or other matters connected with the care of the sick.

The responsibilities of the officer commanding a unit and the proper use of the sanitary squad will not, and must not, be limited to the period during which the unit may be present with a field army, but all must continue to fulfil their respective functions wherever the unit may be located. The same principles and practice must be enforced when the unit is divided into detachments or on the line of march; but when the unit is on the lines of communication or at the base the sanitary arrangements will be supplemented by an organisation of a more stable and elaborate nature, and more adapted to conditions in which the element of mobility ceases to be paramount.

On the *lines of communication* and at the *base* the conditions affecting sanitary effort resemble those met with in a civilised community in times of peace. Extensive and often densely populated areas must be governed, and the civil community, including military employees, reckoned with; for, unless they have a competent public health service, they will inevitably

communicate preventable disease to the army. Further, the constant passage of troops to the front and of details in the opposite direction means the presence of a migratory population whose movements will be a constant menace to sanitary efficiency. To meet these special conditions the organisation of a sanitary service must be extensive and thorough if modern scientific knowledge is to be applied successfully to the prevention of disease. The general features of the scheme have been published in Army Orders,* and they may be summarised in the following way:

On mobilisation a Sanitary Inspection Committee, consisting of a senior officer of a combatant branch as president, with a field officer of the Royal Engineers and a field officer of the Royal Army Medical Corps as members, will be appointed to work under the general officer commanding in chief. This committee will perform duties similar to those of the medical inspection branch of the Local Government Board of the United Kingdom. When necessary it will form sub-committees for local purposes, and be empowered to call on engineer, medical, and veterinary officers for their technical assistance in such cases as may appear to require the special knowledge of these officers. The principal duties of the committee may be outlined as follows: (*a*) To ascertain that sanitary appliances and materials of all kinds required for the army are forthcoming, and that an adequate reserve is maintained; (*b*) to assist general officers and the medical service in their efforts to maintain the health of the army by co-ordinating not only the work of the different military branches, but

* See Army Order No. 3 of 1908.

also the military and the civil sanitary organisations of the area occupied; (c) to initiate schemes of general sanitation, and to serve as a board of reference for the solution of sanitary questions; (d) to visit and inspect places occupied by troops, to advise local authorities regarding sanitary measures, and to further in every way the maintenance of satisfactory sanitary conditions. They will report to headquarters any measures they consider necessary, but which they cannot arrange for locally.

The execution of the various measures proposed by this inspection committee or put forward by local sanitary officers will devolve on the commanding officers of the various posts or garrisons, who will have at their disposal either an ordinary officer of the medical corps or one who has specialised in public health. These sanitary officers will be located at the more important places on the lines of communication and at the base, being in command of and supervising the work of the various sanitary sections and squads wherever located. These sanitary sections and squads will be provided, on mobilisation, by the Royal Army Medical Corps, a sanitary section being given to each base and to each rail head, while a sanitary squad will be allotted to each road or railway post on a line of communication and two sanitary squads to each advanced dépôt. The strength of these sections and squads is given in "War Establishments."* All skilled executive sanitary duties, such as those connected with water purification and disinfection, as well as the supervision of fatigue parties or hired labour employed for conservancy purposes, will be carried out by the sanitary sections or squads,

* "War Establishments," 1907–8, p. 149.

acting under and on the authority of the officer commanding the post. The sections or squads will be further charged with the performance of sanitary police duties, and for this purpose the non-commissioned officer and men of the section or squad will be invested with the authority of sanitary police. If the post has a railway station under military control, the sanitary section or squad will exercise sanitary supervision over the water supplied at the station to troops passing through and over the conservancy, and other sanitary arrangements. The sanitary officer in command will be responsible to the officer commanding the post for maintaining constant supervision over the supply of food and water, the disposal of sewage and refuse, and perform generally the duties incidental to a medical officer of health in the United Kingdom. It must be understood that the provision and allocation of these sanitary sections or squads at posts on lines of communication in no way relieves the commanding officers of individual units of their sanitary responsibilities in respect of their own lines, but are meant to place a permanent *personnel* of trained men at the disposal of the local officer commanding for the systematic sanitary control of the post, irrespective of changes in the composition of the garrison or the comings and goings of details. It is anticipated that by the elaboration of this scheme rest camps and other posts on lines of communication may be rendered sanitarily safe halting-places for those passing through to or from the front. Failure to secure this condition has been the cause of the loss of many lives from preventable disease in most of our wars.

CHAPTER VI

THE RECRUIT

EFFICIENT recruitment being the prime necessity in the organisation of a military force, the intelligence and faithfulness with which this duty is performed constitute an important element upon which the future health, efficiency, and mobility of an army depend. No argument is required to demonstrate the necessity for a careful physical examination of every recruit before enlistment. The principle is recognised fully; so much so that before his enlistment is completed, the recruit is carefully examined by a medical officer. The examination is a strict one, and aims at investigating, as far as possible, the mental condition, the senses, the general formation of the body, the absence of infirmity or injury likely to interfere with his duties as a soldier, the condition of the heart, lungs, and abdominal organs generally, the state of the joints, the condition of the feet, absence of hernia, varicocele, &c., and his power of vision.

The British army being enlisted on the voluntary system, the terms of enlistment are liable to vary according to the national requirements of the time, but at present they stand at either eight years with the colours and four in the reserve, as for Household Cavalry

and Garrison Artillery; or seven years with the colours and five years in the reserve, as for Cavalry and Infantry of the line; or six years each with the colours and in the reserve, as in Horse and Field Artillery; or three years with the colours and nine in the reserve, as for sappers in the Engineers, men other than bandsmen in the foot Guards, men for the Medical Corps, and men other than drivers or artificers in the Army Service Corps and Ordnance Corps. Drivers in both the Engineers and Army Service Corps serve two years with the colours and ten in the reserve, while bandsmen in the foot Guards and Army schoolmasters serve twelve years with the colours and no period in the reserve. The terms of service in various Colonial corps are special, and need no detailed recapitulation here. The limits of age at which recruits are taken are from eighteen to twenty-five years, but in some sections of the technical corps the limit may be extended to thirty or even thirty-five years. Boys, however, may be enlisted as drummers. Recruits must be of a certain height, which varies with the supply of men volunteering for military service and for different arms of the service. For the Household Cavalry it is from 5 ft. 11 ins. to 6 ft. 1 in.; for the Cavalry of the Line from 5 ft. 4 ins. to 5 ft. 7 ins. if under twenty years of age, and from 5 ft. 6 ins. to 5 ft. 8 ins. if over twenty years; for gunners in the Artillery the height must be from 5 ft. 7 ins. to 5 ft. 10 ins., while the drivers vary from 5 ft. 3 ins. to 5 ft. 7 ins.; in the Engineers the limits of height are from 5 ft. 5 ins. to 5 ft. 7 ins.; for the foot Guards men must be 5 ft. 7 ins. if under twenty years of age, and 5 ft. 8 ins. if over twenty; in the Infantry of the

Line and the Medical Corps the height is 5 ft. 3 ins. and upwards; drivers in the Army Service Corps vary from 5 ft. 2 ins. to 5 ft. 4 ins., and other recruits from 5 ft. 3 ins. to 5 ft. 6 ins.; in the Ordnance Corps ordinary recruits range from 5 ft. 3 ins. to 5 ft. 5 in., while artificers and armourers are taken at 5 ft. 4 ins. and upwards. Certain standards of chest girth when fully expanded are laid down in Appendix II. of "Regulations for Recruiting." These need not be quoted in detail, but no recruit may be enlisted who fails to fulfil the conditions of chest measurement or chest expansion laid down. The chest measurement of recruits is taken by medical officers under specified directions given in the medical regulations, but a definite amount of expansion is required, according to height and age. The minimum of chest girth is taken when the lungs are emptied of all air. In general terms, the acceptable chest girth when fully expanded is a minimum of 33 ins., ranging, under certain conditions of age and height, to 38 ins. The expansion demanded is a range of not less than 2 ins. as expressing the difference in girth between an expanded chest full of air and one contracted when the lungs are emptied of air. There is no standard of weight for recruits, but certain weights are laid down in the various schedules which serve as guides. These vary according to age and height, and range from 112 lb. for a lad of eighteen years and 5 ft. 2 ins. tall to 133 lb. for a man of twenty-two years and 6 ft. in height.

The importance of a due correlation of height, weight, and chest measurement in estimating physique as a whole has long been recognised, good weight for

height being the first need. An easy rule is that up to 5 ft. 7 ins. twice the height in inches ought to be about the weight in pounds, adding 7 lb. for every inch above 67 ins. According to Broca, the weight in kilogrammes should correspond with the number of centimetres in stature above 1 metre. Foreign standards place the average increase of weight with the height at about 0·75 kilogramme for each centimetre of stature. Since many young men of excellent bone may be temporarily under weight owing to defective nourishment, this standard of weight may be left to the discretion of experienced medical officers. Our experience indicates that the weakness of many of these weedy recruits is apparent rather than actual. A recruit's weight after a few months' service is influenced often by his calling before enlistment. Men coming from sedentary occupations, such as clerks, tailors, saddlers, and so on, put on weight very quickly, whereas those who have had opportunities of over-feeding, such as bakers, brewers, butchers, and confectioners, lose it with a corresponding rapidity. Recruits recovering from illness, or who have had to work and live under defective sanitary conditions, may safely be accepted when below an arbitrary standard, for their weight is sure to increase; and the same rule applies to youths brought up in poverty.

There is a tendency among some to accept height as a satisfactory expression of constitutional force and suitability for military service. This is based upon a misconception, since the vital resistance of an individual is closely related to the symmetrical development of all parts of the body. It is of much more import-

ance that the soldier should be strong than that he should be tall, and in the military service of the present day little necessity exists for men above the mean in size. The average stature of a youth of eighteen years of age is a little over 64 in., and this increases gradually until he reaches the age of twenty-five years, when his average height is 67½ ins. In foreign armies the minimum height of the soldier is at present fixed as follows: Austrian, 60 ins.; Belgian, 61 ins.; French, 60 ins.; German, 62 ins.; Italian, 60 ins.; Portuguese, 59 ins.; Russian, 60 ins.; Spanish, 59 ins.; Swedish, 63 ins.; Swiss, 60 ins. It is a well-known fact that very tall men cannot support for long periods the fatigues of arduous military service, and excess of height in the absence of proportionate general physical development is as much a cause for rejection as a deficiency in stature. For all arms of the service the enlistment of muscular men of medium height is most desirable.

The measurement of the chest capacity is of great importance in determining the vigour of the recruit, in that the thorax or chest contains the heart and lungs, which are the vital machinery representing the staying power of the man. It must therefore be ample to ensure that the quantity of air introduced into the lungs at each inspiration is sufficient. Mobility of the chest is in this respect an important point to record, especially with reference to its relation to height and weight. Chest mobility does not, however, necessarily mean chest capacity; but where mobility or expansibility is good capacity is usually satisfactory. Experience shows that the maximum

range of mobility of the chest in a man of average size between eighteen and twenty-five years of age is from 2 to 2½ ins., and in our recruiting tests this figure is demanded. In our own service the minimum measurement on full expansion of the chest is placed at 33 ins., but in some Continental armies as little as 31 ins. is accepted. In a well-proportioned man the chest measure should exceed half the height by from 1 to 1½ ins. Seggel, as the result of a large number of measurements, attaches importance to the width of the shoulders in the examination of recruits. He takes the measurements with the arms hanging at the sides or held straight out in front of the body; the width of the shoulders should not be less, in a properly built man, than two-ninths of his height, the minimum being one-fourth of the height.

No matter from what point of view we look at the physical development of the individual, we find that age is the dominant factor. The minimum age at which the recruit may be enlisted in our service is eighteen years. From the standpoint of developmental anatomy the soldier should certainly not be enlisted before the age of twenty-one. At eighteen years the bones are not fully formed, and their actual growth continues until the twenty-fifth year. This same age-period is that in which the greatest growth of the heart takes place, and when cardiac development is deficient heart-failure is liable to occur under severe exertions. This is in accord with everyday experience, as it is the young soldier who has the highest ratio of morbidity and mortality, whether in peace or war.

Taking the latest information available as to the

physical development of the recruit enlisting into the British army at home, we find his average age to be 19·3 years, average height 65·6 ins., average minimum chest measurement 33 ins., average maximum chest measurement 35·1 ins., average weight 122·7 lb., and average range of chest expansion 2·5 ins. This may be taken as the physique of the typical recruit of our day. The average height of the males of the general population between eighteen and nineteen years of age is 67 ins., and their average weight is 138 lb.

The trades and previous status of the men furnishing our recruits vary greatly from year to year, labourers, servants, and husbandmen forming the larger proportion generally, and manufacturing artisans contributing the next larger number. As might be expected, the town-bred applicants for enlistment are not physically equal to those from the country; but, on the other hand, the consensus of opinion is that men from the rural districts break down more readily under military conditions than do those from cities. The urban youth may be less stalwart in body, but his mind and body are usually active, and he represents the survivors in a struggle for existence which his companion from the country has not had to endure. Broadly speaking, the new conditions of Army life disturb both classes, but to the town-bred man less immediate inconvenience follows. Once he has settled down, the country man may show greater endurance than the city or town lad, but in these days of short service this greater staying power of the bucolic has fewer opportunities to display itself than formerly. In one physical feature the rural recruit is usually superior to the

urban, and that is acuity of vision. The standard of vision for all recruits, except those for the corps of Army schoolmasters, is fixed at (*a*) a quarter of normal acuteness of vision in each eye, or (*b*) $\frac{6}{36}$ vision in one eye, provided the vision in the other eye is normal. In each case the eye is tested without glasses. The experience of recruiting medical officers is that imperfect or defective vision increases with ascent in the social scale. It is, on the whole, less perfect among the better than the lower class of recruits, and among the town-breds than among those from the country.

Of the applicants for enlistment a considerable proportion are summarily rejected by recruiting officers prior to any physical examination. Such rejections are not made a matter of official record. Of those admitted to the physical examination, roughly, 32 per cent. are rejected on inspection, and a trifle over 1 per cent. are further found unfit within three months of enlistment. Taking the latest figures available, or those for 1906, we find that of 62,371 recruits inspected 19,916 were rejected on inspection and 661 were unfit within three months. Out of each 1000 recruits 810 came from England and Wales, 100 from Ireland, 82 from Scotland, and 8 from colonies. The ratios rejected were 33 per cent. of those from England and Wales, 31 per cent. of those from Ireland, 34 per cent. of those from Scotland, and 24 per cent. of those from the Colonies. Among the more important causes of rejection on primary inspection we find the following: Under chest measurement, 67 per 1000 examined; defective teeth, 40 per 1000 examined; defective vision, 38 per 1000 inspected;

flat feet and other defects of lower limbs, 30 per 1000 examined; under weight, 25 per 1000 examined; defective heart action, 18 per 1000 examined; under height, 17 per 1000 examined; and having varicose veins, 14 per 1000 inspected. Of those rejected within three months of enlistment, the greater number are on account of either defective teeth or disordered action of the heart, the actual ratios per 1000 being 2 and 1·5 respectively.

CHAPTER VII

PHYSICAL TRAINING OF THE SOLDIER

After the recruit has been enlisted and approved he joins his dépôt or his regiment, receives his kit, and is put on the soldier's rations. He enters at once on his drill, which occupies from three to four hours daily, and takes his turn in various fatigue duties. With a view to assist in the physical development of the soldier, the majority of recruits, notably those in the artillery and infantry, undergo a special course of physical training. These exercises last for an hour daily, and are in addition to the man's ordinary drill. The training is conducted mainly in gymnasia by a specially trained gymnastic staff, the whole course being also within the purview of a medical officer, whose function is essentially to see that no ill results follow the various physical exercises.* On completion of his recruit's course, and during each year subsequent to his first year of service, the trained soldier does further physical exercises under squadron, battery, or company officers, in order to keep him fit and in condition for his work as a soldier.

The object of physical training should be the pro-

* "King's Regulations," 1908, para. 688 *et seq.* See also "Manual of Physical Training," 1908.

duction of a state of health and general physical fitness, in order that the body may be able to perform the work required of it without injury to the system. To secure this end it is of the first importance that all physical exercises of the recruit and trained soldier be carried out with due regard to elementary physiological facts and principles. It is not sufficient to develop and train certain external or groups of surface muscles alone and to neglect the heart, lungs, and other internal organs, for it is on these internal parts, notably the heart and lungs, that the body as a whole depends not only for its fitness, but for its very existence. Failure in the past to recognise this fundamental idea has been the cause of much undoubted harm to the young soldier, who, after all, is in the majority of cases but an immature man. The considerable leakage from the Army of men who are invalided for disordered action of the heart has for many years been a matter for concern. Careful inquiry indicates that this disability, almost peculiar to the service, is caused by the service, owing to faulty physical training on the parade ground and in the gymnasium, before the soldier is subjected to any adverse climatic or other non-preventable influences. Last year's returns show that 472 men were invalided from the service, or about 2 per 1000 on strength, for either valvular disease of the heart or heart strain. The average loss under this head for the previous ten years was 3·93 per 1000. This notable reduction can be largely attributed to improved methods in physical training recently inaugurated.

Whatever part physical training plays in the production of heart disease in the Army, it is evident that

a proper system of training should serve some useful purpose, and should not cause any effect which is known, on physiological grounds, to be injurious to any organ of the body. Too much faith has been placed in the past on heavy dumb-bells and in pulling the body up to horizontal bars by sheer strength of arm. It must ever be remembered that a man is only as strong as his heart, whatever be the size of his arm, and that no training is of any value which damages the great internal muscle of the body, the heart. The muscular efforts made in performing the majority of physical exercises, certainly those under earlier regulations, interfere with the respiratory movements of the chest, and thereby prevent the free circulation of the blood through the lungs. If this occur, the blood is dammed up in the right side of the heart, leading to dilatation or stretching of the cardiac chambers, and consequent strain of the organ. In protracted cases both sides of the heart may become affected, when the results are both serious and permanent. How this comes about will be better understood by a study of the accompanying diagram of the circulation of the blood (Fig. 3). It will be seen that the heart is divided into four chambers, two on the right and two on the left. The right side of the heart receives venous or impure blood from the body, and at once pumps it into the lungs to be oxygenated and made pure; this vivified blood then flows from the lungs to the left side of the heart, whence it is forced or pumped through the great arteries to the various parts of the body, where it is collected by the veins and flows back to the heart again. Any obstruction to this free circulation of blood necessarily entails

Fig. 3.

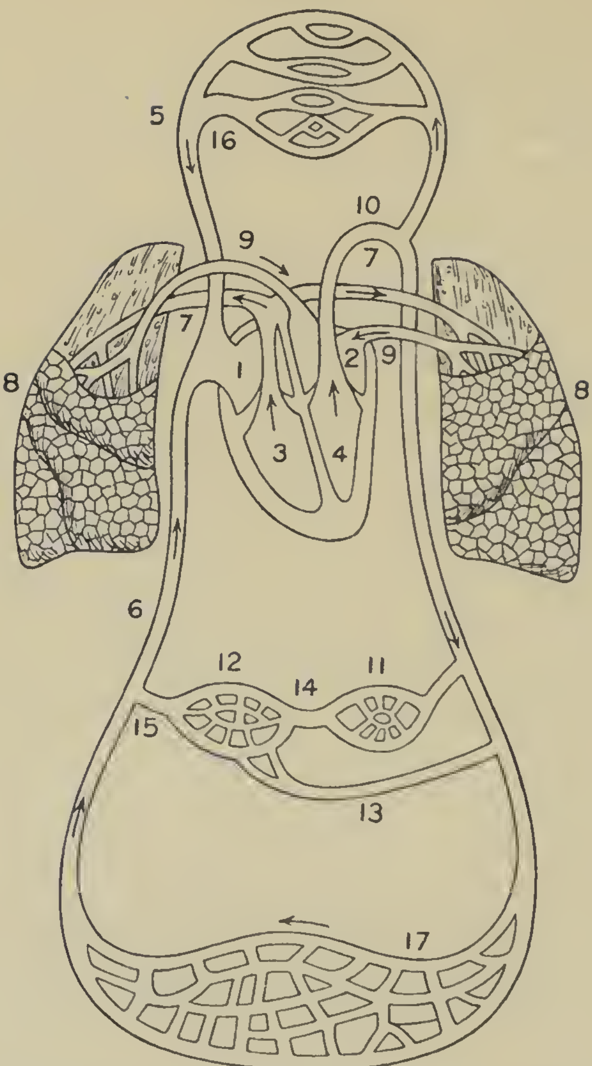


Diagram Illustrating the Circulation of the Blood. 1, right auricle of heart; 2, left auricle of heart; 3, right ventricle of heart; 4, left ventricle of heart; 5, large vein bringing blood from the head and upper extremities to the heart; 6, large vein bringing blood from the liver and lower extremities to the heart; 7, large vessels conveying venous or impure blood from right ventricle of heart to the lungs; 8, the lungs; 9, large vessels conveying purified blood from the lungs to the left auricle of heart; 10, the aorta or large artery conveying pure blood from the left ventricle of heart for distribution to various parts of the body; 11, the alimentary canal; 12, the liver; 13, artery conveying blood to liver; 14, portal vein conveying impure blood from intestines to the liver; 15, vein conveying blood from the liver; 16, circulation through head and upper extremities; 17, circulation through the lower extremities.

increased strain or work on the heart itself, which is nothing but a mass of muscle undergoing continuous rhythmic contractions and dilations.

No advantage can accrue by teaching soldiers to be good acrobats or slow heavy-weight lifters. Activity, good powers of marching and endurance are the qualities which should be cultivated. There is no rapid method of making a man capable of withstanding prolonged exertion; he must be well fed, and his work must be tempered to his habits. The smoker and man who indulges in alcohol cannot, other things being equal, get into condition so quickly as the non-smoker and abstainer; therefore the training of the soldier, who in most instances is neither a non-smoker nor an abstainer, must be gradual and of a mild character. The whole of the physical training, including "running drill," must be carried on under the supervision of instructors who have at least a working knowledge of elementary physiology. Such training should not take place before breakfast, and should be limited strictly to one hour a day. Moreover, no recruit should begin physical training until he has one month's service. By this time he will have been well fed and accustomed to his new life. The recruits should be passed from a lower to a higher squad individually. Above all things it must be understood that the object of true physical training is not to develop large muscles, but to accustom the heart and lungs to sustained effort. All the muscles of the body, including those of the heart and lungs, should be exercised equally, taking care that no one muscle is overworked. The exercises should be changed at frequent intervals, with suitable

periods of rest, and increased effort demanded gradually. The periods of rest must be such that the muscle fatigue disappears completely before work is resumed. The respiratory movements should never be interrupted or in any way hampered; if they are it means an engorging of the lungs with blood, entailing a corresponding strain or greater effort on the part of the heart to force the blood through them. No part of the training should be carried to the point of causing distress, and in most cases this means that the pulse beats should not exceed 120 per minute. When there is distress, as evidenced by hurried breathing and persistently rapid pulse, it is to be inferred that the exercises are doing harm rather than good, that the rhythmic action of the heart and respiration is embarrassed; in other words, the lungs cannot be cleared of the blood quickly enough, or, if they are so cleared, it is secured only at the expense of the heart muscle. Prolonged or repeated physical effort under these conditions means heart strain and all the troubles which invariably follow it.

The best and proper exercises for the physical training of the recruit or trained soldier are steady practice in marching or walking, running, skipping, balancing, jumping, vaulting, and fencing. These are quite sufficient to teach the heart and lungs to work together without pain or embarrassment, and prepare the man for the actual duties of the arm to which he belongs. A short run will expand the lungs far better than exercises on the horizontal bar; the only instruction in breathing necessary is to tell the men to breathe through the nose as much as possible, and not through the

month. The various exercises in climbing and scaling obstacles should be regarded as purely military instruction, and not repeated or practised in order to improve physique.

Passing from the recruit to the trained soldier, we find the work he does difficult to estimate, so much depending on the corps or branch to which he belongs. The artillery have probably the hardest work, which comprises mostly cleaning horses, harness, guns, carriages, stable fatigues, and drill. The cavalry have very nearly the same amount of work to get through, although their stable duties consist nearly altogether in looking after their horses and saddlery. In the infantry, duties are mostly confined to drills, marches, musketry, and fatigue work in barracks. All these duties, when not excessive, have a beneficial effect; but when severe and violent work has to be done hurriedly the soldier is not placed in the same favourable condition to carry out the work as the ordinary mechanic would be; this is largely due to the fact that in drills the position is more or less strained, while the nature of his dress and equipment adds to the work which a soldier is called upon to do. The position of attention is far more injurious to the young soldier than many appreciate; the movements of respiration are seriously checked in the effort to appear smart and keep the chest expanded. After a time the chest walls become more or less fixed in a position of expansion, and the range of expansion is permanently diminished. This state of matters reduces the efficiency of the lungs, and thereby of the aeration of the blood, inducing not only a lessened ability to resist disease,

but also a diseased or over-strained heart. We can never tolerate men being slovenly in gait or bearing; but, on the other hand, the desire to make men "smart" can be carried too far, as excessive "smartness" in drill is an undoubted factor in generating heart strain in very young soldiers. We have no wish to labour this point, but it is necessary that the facts should be understood.*

In closing this chapter it is desirable to recapitulate the following principles, adherence to which should constitute the basis of any scheme for the physical training of the soldier:

(1) The true object of physical training being the increase of the recruit's strength, agility, and capacity for muscular work, the uniform development of all the muscles of the body is unnecessary and uneconomical. The soldier should specialise according to his work, marching and digging being exercises in which infantry soldiers require progressive training.

(2) The position of "attention" is an abnormal position which can be defended only as a discipline. In marching and other military exercises the natural movements of the arms and the swing of the body should not be suppressed. Exercises which produce prolonged fixation of the chest during muscular work are unsuitable for recruits.

(3) The natural method to improve the "wind" is progressive running. A good "wind" is something more than a big chest; it is the capacity of the heart

* The student interested in this question should read an article on "The Physiological Principles of Physical Training," by M. S. Pembrey, in the *Journal of the Royal Army Medical Corps*, April 1908, p. 339.

and lungs to accommodate themselves to the demands made upon them by muscular exercise. Training involves the education of the recruit to an outdoor life. Work in the open air hardens a man, diminishes his liability to "colds," consumption, and other infectious diseases, and improves his appetite and nutrition.

(4) Games have a more beneficial effect than irksome exercises. Obstacle races, wrestling, boxing, swimming, bayonet fighting, and fencing are to be encouraged rather than exercises with the horizontal bar, parallel bar, pair of rings, Indian clubs, dumb-bells, and span-bending. This last-named, together with abdominal and dorsal exercises, is not free from danger.

(5) Military competitions and displays should con sist of exercises of military value. All official tests of proficiency should be those which bring out a recruit's capacity to co-ordinate his muscles, to accommodate himself to the demands of muscular work, and to bear fatiguing exercises without undue distress.

CHAPTER VIII

THE BARRACK

BARRACKS have been in our army, and in many armies of Europe still are, a fertile source of illness and loss of service. At all times the greatest care is necessary to counteract the injurious effects of compressing a number of persons into a restricted space. In the case of soldiers the compression has been extreme in the past, but, thanks to the better recognition of sanitary principles, the general housing of the soldier in the present day is fairly good. The plans on which barracks were formerly built exhibit every possible variety as regards design and internal arrangement. In many cases the chief object in view appears to have been to place as many men as possible on the ground at disposal. Space will not permit of a review of this interesting section in military history; the most that can be attempted is a summary of the principles on which the home of the soldier should be designed.

The selection of the site is of the first importance. It should be open, though not necessarily devoid of trees, fairly elevated, and freely exposed to the atmosphere, although protected from cold winds. The ground around should have a fair fall, to facilitate drainage, with natural drainage outlets, a dry and

porous soil, and be well removed from any undrained marshy land, stagnant water, deep ravines, and nuisances generally. To those called upon to select sites for buildings or camps the value of a visit to the locality in the evening, when conditions are favourable to fogs and mists, is a practical point worth remembering. As for soil, gravel, sand, and chalk form, as a rule, good sites; so do limestone and sandstone. Loams, marl, and clay are not often satisfactory, unless well drained. The worst soil features are shallow beds of gravel or sand overlying clay, reclaimed lands, alluvial tracts, and generally made-up soils. As to subsoil conditions, the most important feature is that the ground water be both deep and fairly constant in level.

Following the considerations affecting the choice of a site suitable for barracks come those which govern the disposition of these buildings on the ground. The aspect or orientation should depend on the purpose which the buildings are intended to serve and on their geographical position. Thus, in a temperate climate we seek as much sunshine as possible, whereas in tropical countries we have to protect barracks and their occupants against the direct rays of the sun. For these reasons we find barracks at home generally built with their long axis north and south and their windows facing east and west; in tropical climates, on the other hand, the comparatively horizontal rays of the morning and evening sun, slanting directly into windows, have to be avoided, and the aspect modified accordingly. These general principles do not apply to such buildings as stores, while the existence of certain winds in hot climates or the exigencies of a site may necessitate

modification of the above rules. Due consideration being given to the foregoing factors, the following notes will suffice to explain the relative positions of barrack buildings with regard to one another and to parade grounds and means of communication.

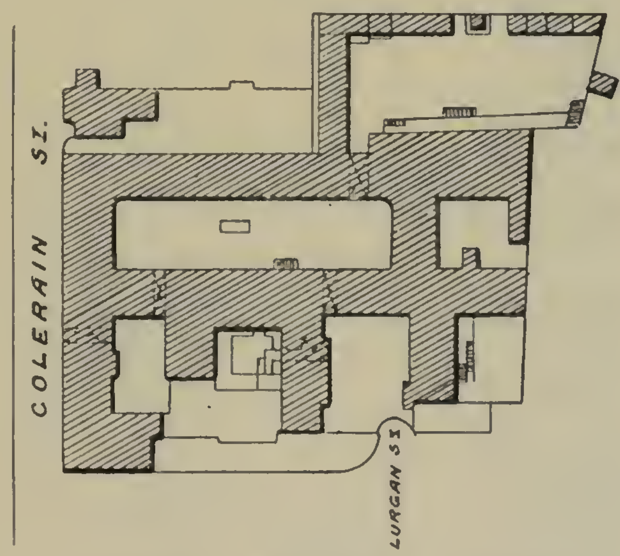
Barrack blocks should be arranged together and adjacent to the parade ground, and for mounted units convenient to stables also. Cook-houses, baths and latrines, and dining-rooms should all be close to the barrack rooms, but not more in evidence than need be. Married quarters, with laundry and drying ground, should be placed in retired positions, and as well screened from the single men's quarters as the site will allow. Canteens and recreation rooms should be conveniently located for both married and single men. The sergeants' mess should have a good frontage, and convenient to the quarters, consistent with not being too near the men's barracks and regimental institutions. Officers' quarters and mess should have the best available frontage, and be if possible on a road not used as a thoroughfare by the men. The quartermaster's stores and his private quarters may be near the officers' mess and equally convenient to the regimental stores and shops. These latter should be arranged on roads for the easy access of carts, while coal-yards need to be located centrally to avoid unnecessary fatigue. The regimental offices and guard-room are best placed at the entrance to the group of barrack buildings which they serve. The parade ground should be of such a size as to measure at least 150 by 100 yards, with a drill shed either adjoining it or conveniently near. The whole place should be arranged with a view to easy approach,

simple drainage, symmetry, and free access of air and sunshine to all occupied buildings. The intervals between occupied buildings should not be less than twice the height from ground to eaves.

These, then, are the various items and their desired relation to each other which have to be worked into any

FIG. 4.

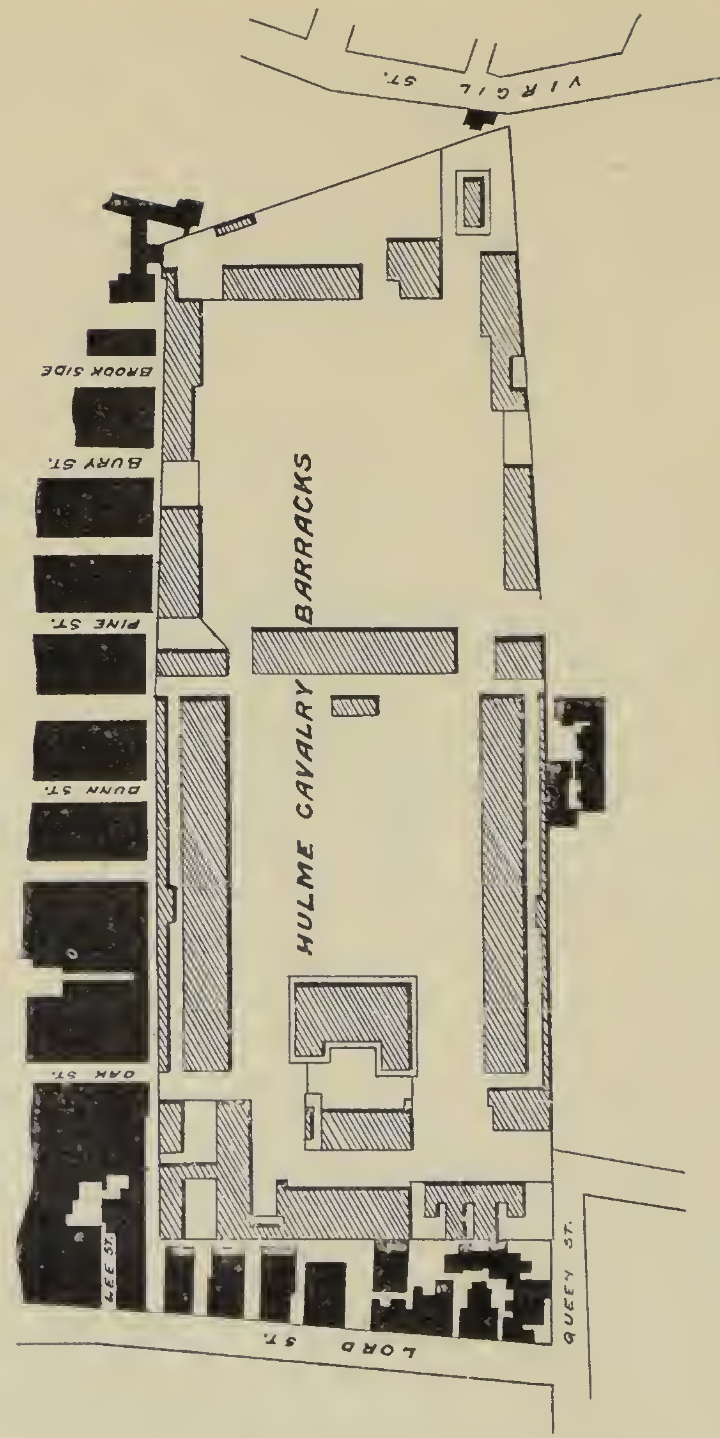
LINEN HALL BARRACKS, DUBLIN



Block plan of obsolete type of Barrack.

design of block plans for barracks. Their successful attainment is not always easy, owing to exigencies of site; but before considering a typical site plan of what a barrack may or should be attention may be directed to Figs. 4 and 5, which represent two instances of what a barrack block plan should not be. The former, an old block plan of Linen Hall Barracks, Dublin, is an instance of abnormal deficiency of internal freedom of

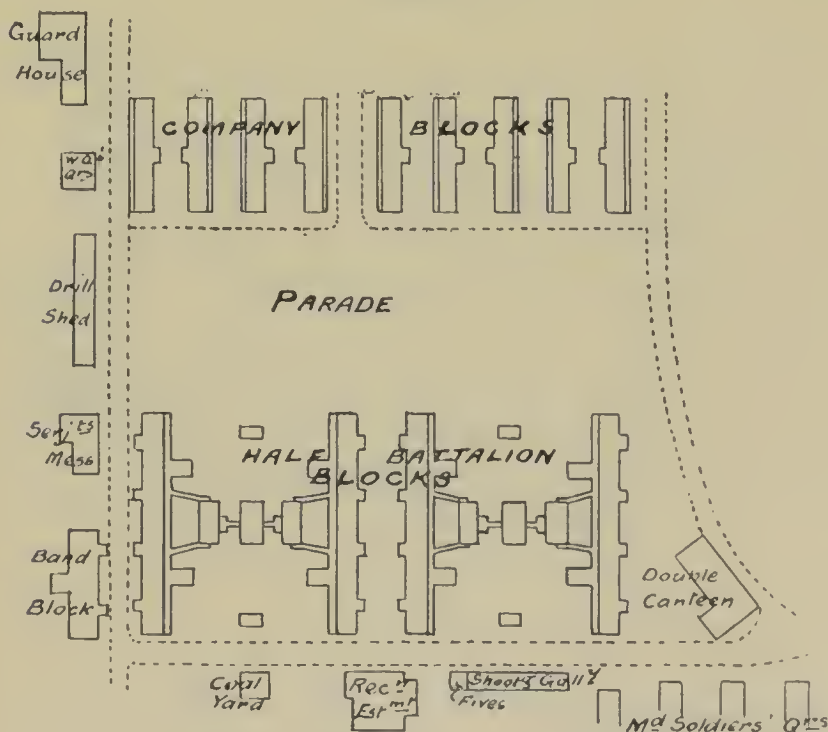
FIG. 5.



Block plan of obsolete type of Barrack.

air circulation, owing to the barracks being too concentrated. Fig. 5, showing a plan of Hulme Barracks, in Manchester, is an excellent example of a most objectionable type of barracks, caused by crowding them against the outer wall, and subjecting them not only to their

FIG. 6.



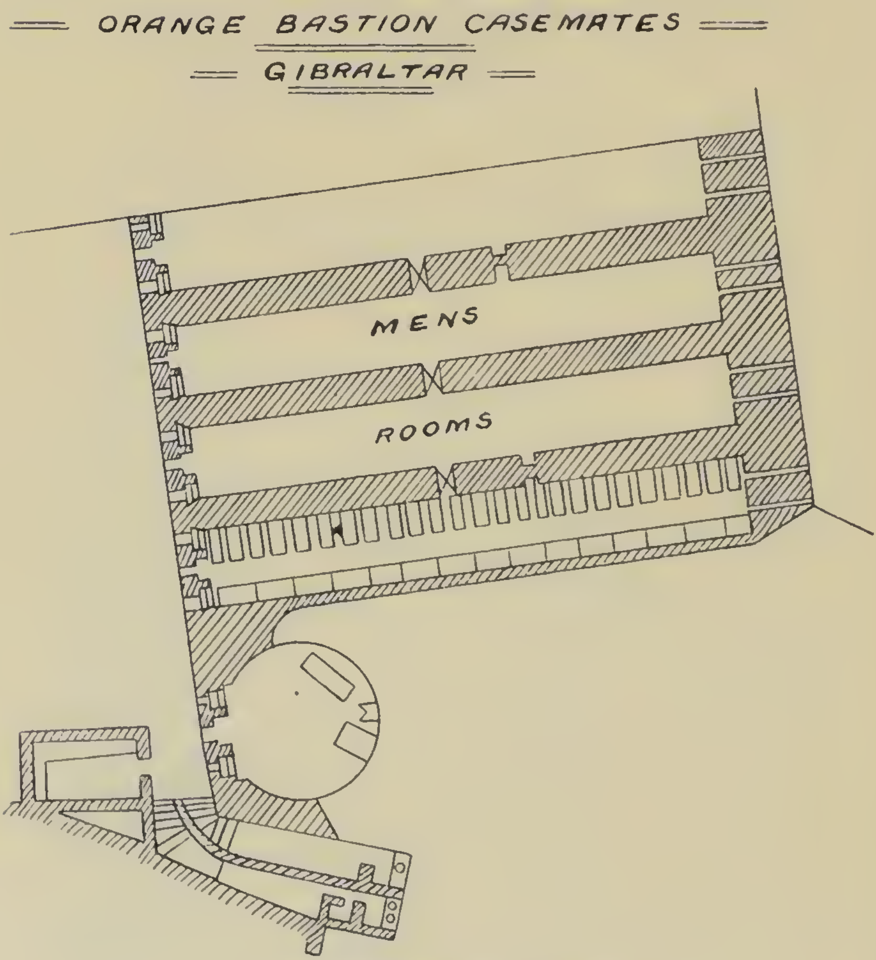
Block plan of old and new type of Barrack.

own nuisances, but also to those of the crowded streets of a very dirty part of Manchester, which touch the barracks all round. Our own experience of these barracks indicates the real facts to be much worse than the drawing shows, owing to the height of some of the surrounding mills.

As representative of what a well thought-out block an for barracks may or should be, Fig. 6 represents

two new barracks at Colchester. These show two stages in design of barrack blocks, namely, the single-company block type in Sobraon Barracks, and the half-

Fig. 7.



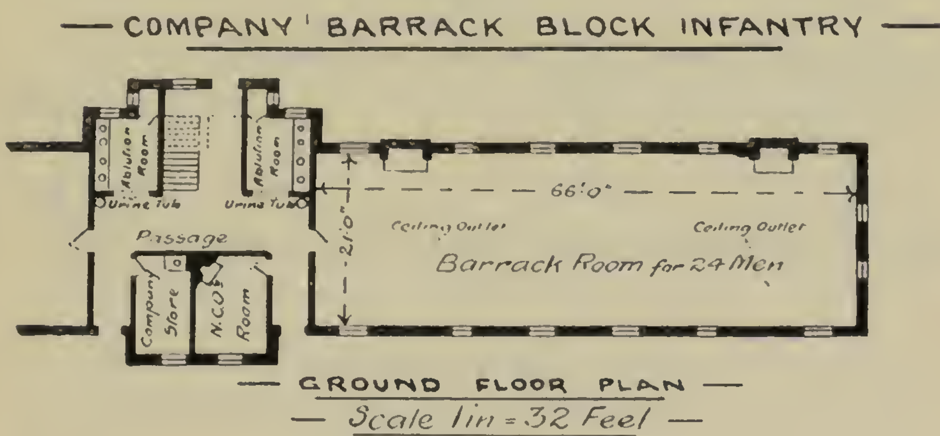
Plan of Casemate Barrack.

battalion combined or verandah type in the Gujerat Barracks. There are certain defects in the plan which are due to limitations of available site, but it illustrates the essential difference between old and new ideas.

We may now consider the plan of actual barrack

buildings. Of these there are many types, but as a rule barracks are best constructed of only two storeys. Frequently the ground floor may be with advantage used for libraries, day rooms, and administrative purposes; but this is not practicable as a rule. Basements should never be utilised as barrack rooms; they are always liable to damp, and consequently unhealthy. Barrack rooms over stables are equally objectionable.

FIG. 8.



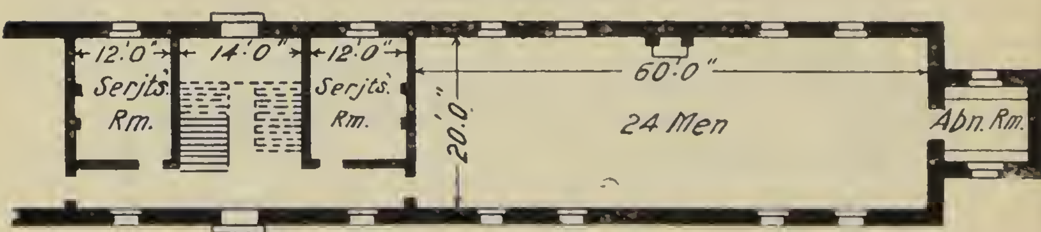
Plan of Barrack Room.

Fig. 7 shows a typical instance of an objectionable kind of barrack building common in citadels and fortresses. In this case, which represents the Orange Bastion casemates, Gibraltar, long lines of beds nearly touching each other are arranged on either side of a lengthy casemate, lighted and ventilated practically from one end only. Such an arrangement would be inadmissible in a modern building, but is difficult to amend in older defensive works.

The Barrack Room.—Although considerable variety exists in respect of general planning of barracks,

the actual barrack room conforms closely to a type. Figs. 8 and 9 show two common forms of the barrack room. These are arranged usually in company blocks, each block consisting of two non-commissioned officers' rooms and four soldiers' rooms, each of which holds twenty-four men, the whole constituting a two-storeyed building, with central staircase. The size of the room is such that each soldier gets not less than 600 cubic ft. and 57 sq. ft. of space. This is the

FIG. 9.



Plan of Barrack Room.

official allowance of space per man, but in actual practice it is largely negatived by the crowding together of cots, with the result that, although the total area available in the room may be in accord with official standards of measurement, the man himself rarely gets the benefit of that opening out which is the fundamental idea in all sanitary dwelling-places. The men's cots should all have their heads not nearer the walls than six inches, while a clear interspace of two feet should exist between each cot.* To place the cots close together, as so often is done, unduly favours the occupants' breathing used-up air emitted from their neighbours, and neutralises the attempt to secure them

* "King's Regulations," 1908, para. 1003, might be amplified with advantage.

a minimum area of floor space. The men's cots cannot be spread out too much, even at a sacrifice of available space in the middle of the room. Our object should be to allow a free flow of air round each individual, consistent with comfort, so as to permit of an adequate dilution of the impurities given off into the air by each man.

These details suggest a consideration of the whole theory and practice of ventilation. Ventilation may be described as an attempt to so deliver air to the occupants of a room that the air in that room may be maintained at an equal degree of sweetness as pure air outside. Air is nothing but a mixture of gases, the most important being oxygen. Pure air consists of a mixture of about 21 parts of oxygen and 79 of nitrogen in 100, some watery vapour, a trace of ammonia and carbonic acid amounting to about 4 parts in 10,000 of air. When a human being or an animal breathes this air he uses up some of the oxygen and imparts certain impurities to it as well. Precisely the same effect is produced by gas, candles, lamp oil, and other materials burning in air. Air as expired by man contains not only about 5 per cent. less oxygen than ordinary air, but carbonic acid in the enormous proportion of 470 parts in 10,000, and is, moreover, heated to the temperature of the body and saturated with moisture. In addition to these changes, expired air contains germs and an organic impurity of perceptible odour, which we recognise as a "stuffy smell." Apart from this, various other impurities in the form of germs are constantly being added to the air of occupied rooms from the skin, clothing, bedding, &c., of the occupants.

When the proportion of carbonic acid in a room, as the result of occupation, is increased from the usual proportion of 4 in 10,000 to about 8, a faint musty odour can be detected by any one entering from the outside air. If it amounts to 10 parts in 10,000 of air, the room is characteristically close and stuffy. As a rule it may be said that if the atmosphere of a room is quite free from unpleasant odour to a person entering from the fresh air outside there is very little fault to be found with the ventilation, as representing the effective change of air. In all efforts at ventilation we aim, therefore, at maintaining this standard, which may for practical purposes be put down as 10 parts of carbonic acid in 10,000 of air, or 6 parts in excess of that normally present in clean air. The question next arises, how much fresh air must be supplied hourly to each man to dilute the impurities sufficiently to keep the air inside an occupied room as good as it is outside. The answer depends mainly upon how much of these impurities man gives off hourly. This again depends upon what he is doing: if sitting still he clearly will give off less impurities than if doing some manual labour or exercise. Taking average adults moving about in a room, it is known that ten such persons will produce 6 cubic ft. of carbonic acid in the hour, over and above that normally present in the air; therefore, if we want to keep the air in that room of such a quality that it will not smell close and stuffy to any one coming in from the outside—that is, be decently ventilated—those ten persons must have 10,000 cubic ft. of fresh air hourly, or 1000 cubic ft. each. If each person were in a space of 300 cubic ft., this would involve the

changing of the air of that space rather more than three times in the hour. Unless the incoming air were warm, this rapidity of change would probably cause a draught, and corresponding discomfort. If the space be 600 cubic ft., the air need be changed less than twice in the hour, which, even if the incoming air be cold, is not inconsistent with comfort, provided it be discharged or brought into the room space well above the heads of the occupants. This space of 600 cubic ft. is precisely what the soldier gets in his barrack room, and if the air be changed one and two-third times hourly a reasonable degree of ventilation is secured.

The ordinary appliances in barracks for the inlet of fresh air and the discharge of foul air are doors, windows, fireplaces, and louvred ventilators communicating by means of perforated bricks with the outside through the external walls. It is incumbent upon all concerned to see that these are used intelligently and effectually. The fire, when burning, is mainly an outlet for foul air, but most barrack rooms have what is called a ventilating grate, by which air is not only extracted by the chimney, but air coming in from outside and passing round the back of the grate is first warmed and then discharged into the room by a grating above the fireplace. In each barrack room special outlets are provided at the rate of not less than 1 sq. in. clear cross-section area to 60 cubic ft. of room space. Fresh air inlets are also provided at the rate of 1 sq. in. to every 60 cubic ft. of room space, except where ventilating grates are used, in which case 1 sq. in. to every 120 cubic ft. only is required, the grates being

constructed to supply half the necessary amount of fresh air, warmed to 60° F. Cold fresh air should be admitted in an upward direction at a height of 8 to 10 ft. from the floor; warm air inlets of ventilating grates should not be more than 8 ft. above the floor. In a barrack room two outlet shafts, each 14 ins. by 9 ins., are provided; also eight inlet shafts, five with an area of 10 sq. ins. and three with an area of 20 sq. ins. There are two ventilating grates in each barrack room, the air shafts being arranged to supply half the fresh air required. The external openings of the air ducts are placed above the damp-proof course, and not less than 18 ins. from the ground. These arrangements are ample, and require only ordinary intelligence for their satisfactory use. When weather permits, windows should be kept wide open all day, and the upper sashes open at least three inches at night all the year round.*

Although much has been done in recent years to improve the general standard of comfort for soldiers in barracks, it must be confessed that even now the average barrack room is far from being a cheerful and commodious home for a man of a sensitive nature. In this country the two chief defects in ordinary barrack rooms are inadequate lighting and heating. The main obstacle to amendment lies in the financial question involved, but we think this to be exaggerated. To substitute better types of fire-grate in barrack rooms in lieu of the so-called ventilating Galton grate would not involve an enormous outlay of public money; neither would the provision of more numerous and better gas

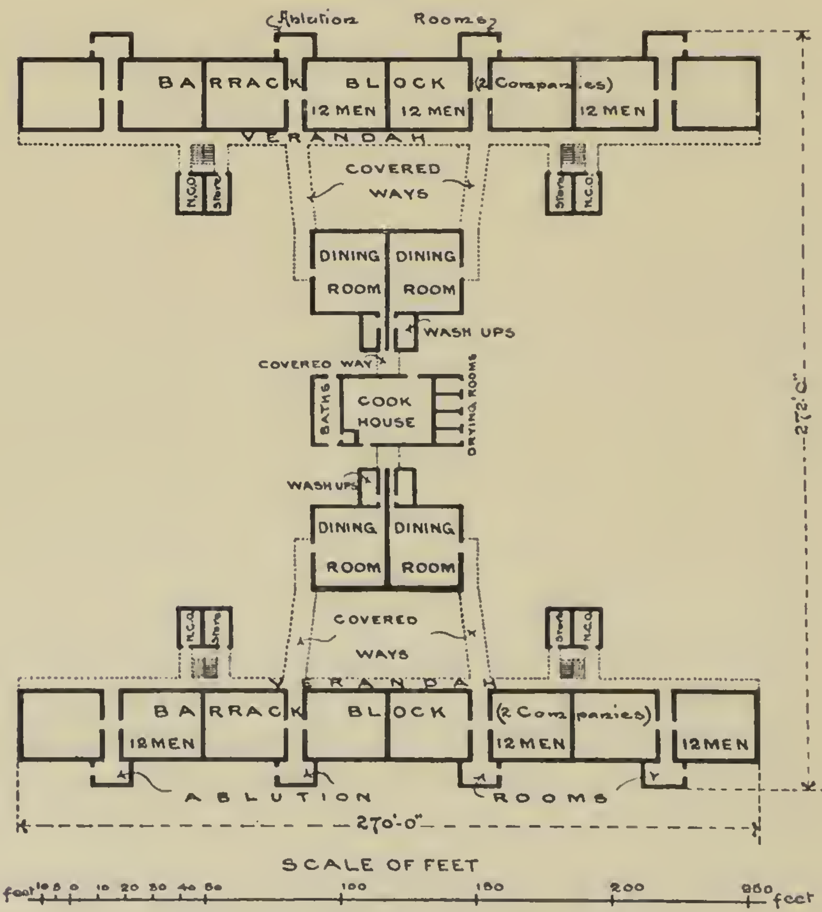
* "King's Regulations," 1908, para. 1003.

or electric lights in place of the present sparse and feeble sources of artificial illumination. The ventilation of barrack rooms, which once was much neglected, is fairly satisfactory at the present time. If anything, we think the tendency in the immediate past has been to rather over-ventilate; now, however, the part played by smoke flues as outlets and leaky doors and windows as inlets is better understood, and the provision of needless ventilators avoided.

One of the most glaring and objectionable faults existing in the old type of barrack is the absence of dining-halls for the men, the result being that the barrack room is at once sleeping room, living room, and eating room, a combination of functions which, while bad enough for a single occupant, becomes intensely so when the unit space is common to some score or more of individuals. It is to obviate some of these objections that the new half-battalion combined barrack has been designed; this type may be taken to represent the most modern arrangement of barracks in the service. The complete element is shown in Fig. 10, and consists of two double-storeyed blocks, each holding two companies, facing inwards towards dining-halls, and cook-houses built between them, and communicating with them and with each other by means of verandahs and covered ways. These blocks are arranged in twelve-men rooms, with passages between, leading from the verandahs on the inside to ablution rooms on the outside, there being a through communication *via* the latter on the ground floor. This, the most recent arrangement of ablution rooms, is a distinct sanitary improvement. So is the reducing of the barrack room

itself to accommodate only twelve men: this smaller size renders the room much more homely, and facilitates the squadding of the men on some principle of mutual compatibility, while at the same time lending itself

Fig. 10.



Half-Battalion Barrack (Verandah Type).

either to extension or cubicle construction. This last idea will not, we think, be satisfactory in the Army; the majority of the rank and file are against it, and, from trials of the system which have been made, it interferes with that free perflation of air through the

rooms so desirable to be maintained in all soldiers' barrack rooms; it is, moreover, prejudicial to discipline. In a few words, the modern barrack room may be described as a room 36 ft. long by 23 ft. 6 ins. wide, and 10 ft. 6 ins. high. It accommodates twelve men, and has three windows, $2\frac{1}{2}$ ft. by 6 ft., on each side. A bed is placed in each corner, and the others in pairs in the spaces between the windows. At the end of the room opposite the door is a fireplace of glazed fire-brick, with solid hearth; in connection with it is a warm air inlet and a foul air outlet. In addition louvred ventilators are placed in the walls between the beds at a height of 8 ft. from the floor. At the other end of the room is a small ventilated cupboard for storing cleaning materials. No food is allowed to be kept in this cupboard or in any part of the barrack room. Rooms of this type are amply ventilated and afford sufficient space, being at the same time bright, homely, and readily kept clean.

The dining-room block is shown divided into two company dining-halls, which communicate through company wash-up rooms direct to the serving windows of the cook-house on either side. This arrangement, while facilitating the rapid and hot service of meals, enables the crockery and food remains to be kept outside the dining-halls and barrack rooms. The cook-house is arranged for the double service, and at either end are provided bath-rooms (four for men and one for N.C.O.s) and drying-rooms (one per company). The latter, as well as the dining-halls, are heated from a boiler room in a basement below, which supplies also the hot water for use in bath-rooms, cook-house, and

the wash-ups. The rooms for N.C.O.s, with the company stores and staircases, are located on the inner side of the barrack-room block verandah, opposite the centre of each company. The windows to the barrack rooms are of special design, to permit of the ready conversion of the rooms into dormitories with separate cubicles for each individual soldier. The estimated cost of these half-battalion barrack blocks is, notwithstanding the greater advantages and conveniences, very little more than that of similar accommodation provided separately on earlier plans.

The barrack accommodation for a cavalry regiment is based upon the organisation of the unit, viz., the squadron. Each regiment has a pair of barrack blocks arranged in the same manner as the infantry company blocks. Barrack rooms should never be placed over stables.

Closely associated with the barrack room and the life of the soldier therein are a number of matters of importance, which, although strictly personal to the soldier himself, need for efficient control individual interest from his officer. Items of this nature are adequacy and effective use of washing places, personal habits of the men, cleaning of barrack rooms, airing and changing of bedding, storing of food in barrack rooms, and the proper use and care of urinals and latrines.

Each barrack block has two *ablution rooms*, basins being allowed at the rate of 14 per cent. of strength. From a sanitary point of view these places call for no special remark. Baths and bathing accommodation are not on a satisfactory basis in most barracks. The main diffi-

culty is the provision of enough hot water. It is futile to expect the soldier to take a bath, except in the summer months, unless warm, if not actually hot, water is available. We recognise this as being a difficult question, and only capable of true solution by the centralisation of bathing facilities in one or more large baths, according to the size of the garrison, where the allowance of fuel can be economically utilised. It is more or less useless to expect a series of baths to be supplied with water heated from a company or double-company cook-house. In certain units effective use is made of this faulty system, but its success is dependent entirely on administrative initiative within the units. If this is wanting, the facilities for hot baths in barracks are intermittent and inadequate. Every soldier should be made to have a bath at least once a fortnight, and should show at each kit inspection a bathing card, on which should be shown the place and date of bathing. Failure to have had a proper bath in this interval should be the subject of disciplinary measures. Laxity of supervision on these lines leads to prevalence of vermin, and an appreciable amount of inefficiency. The keeping of dogs or other animals in the barrack room should be strictly forbidden.*

The routine *cleansing of barrack rooms* leaves much to be desired. Dry scrubbing of floors should be a daily and wet scrubbing a weekly procedure. The use of sand on the floors of barrack rooms is objectionable, as tending to cause dust and untidiness. The system of sluicing down the room with bucketfuls of water, and then propelling the resulting mess out of the door and

* "King's Regulations," 1908, para. 1008.

down the passage or stairs with the aid of the "long-handled scrubber," has nothing to recommend it; it does not clean, it leaves the floor damp for days, while the water passes through the boards into the ground, or into the ceiling of the room beneath. The results in either case are objectionable. The soldier should be made to scrub out his room on his hands and knees, with soap and water and an ordinary scrubbing-brush, as the sailor does. Mops, scrubbing-brushes, and pails should be kept in a cupboard with a slate floor, altogether outside the room. The same mop used for cleaning up urinals should not be employed for barrack room floors. Too often these articles are kept in a corner of the room, and, being damp, make the floor wet, and cause the sour smell one so often notices in barrack rooms. Those convenient articles, door-mats, dust-pans, and brushes, are not at present officially recognised, yet they are labour-saving contrivances which could not fail to reduce the amount of floor washing required. The pernicious habit which soldiers have of placing their blankets on the recently washed floor as a mat or carpet is to be discouraged. The blanket gets full of dust and filth off boots, is rarely well shaken, and affords a ready means of conveying all kinds of germs to the mouth and nostrils of the man when he uses it as part of his bedding. Speaking of bedding, how often is this *aired* and *shaken out?* Rarely, and often not at all. The sheets are changed monthly, and the blankets once a year.* In all corps the men's bedding should be systematically turned out

* "Regulations for Supply, Transport, and Barrack Services," para. 427.

of the rooms once a week, well aired, and well shaken. How many officers realise that from 6 to 10 per cent. of men wet their bedding at night, at least once a month? Yet such is the case. Further, when one remembers the constant traffic in and out of a barrack room, the ever-present dust, is it any wonder that these articles are dirty, or that the private soldier suffers more from sore throat than any one else. This affection is caused by minute germs constantly present in dust and road- or floor-sweepings. Its incidence could and would be materially reduced, if not abolished, by more care and attention being paid to keeping the blankets and bedding clean. So, again, when a man goes into hospital greater care is needed in the company or squadron stores to keep individual men's blankets distinct, and thereby prevent the blankets of a possibly infected man being mixed up with or mistaken for those of some one else. Far too much laxity prevails in regard to this matter of blankets and bedding. It is the same in regard to a man sent to the detention barracks. Many of these men of indifferent character are dirty in their persons. Their bedding and blankets, like those of men admitted into hospital, should be ever regarded as open to suspicion, and in possible need of disinfection before many days are over. Every man's blankets, &c., should be marked by a distinctive tally, and set aside until he rejoins his unit from either hospital, furlough, or the detention barracks. Such a system would facilitate the sending of the right articles for disinfection as soon as intimation is received that such is necessary. In many cases the medical service has no guarantee that a given pair of blankets were really

used by so and so, with the result that, though so many blankets may be sent for disinfection on application, these need not be the infected ones, they really being in use by some one else, who is placed in the most favourable condition to pick up infection from them. It is the duty of every company, squadron, or battery officer to see that such mistakes do not occur. Unless it is done the doctor's chance of controlling infection is a small one.

The desirability of keeping a room specially set apart for meals has been mentioned. Closely associated with this matter is the question of *food storage*. Facilities for this are notoriously defective in barracks; the result is that men store or reserve food in their kit-boxes full of dusty clothing, or perhaps in cupboards or on open shelves. Every dining-hall should have suitably designed lockers or safes in which men could reserve or keep back uneaten food with some reasonable chance of its remaining sweet and clean.

Another matter which needs attention is the arrangements for *washing up* plates and dishes. In all cases the sanitary orderly of the company, under the N.C.O. of the room, should superintend the washing up after every meal and be responsible to him. All cans, dishes, plates, mugs, knives, forks, tubs, and other utensils used at meal times or for food storage should be scoured and cleaned on the scullery table of the squadron, battery, or company, and not placed on the floor or taken to outside taps. A large tin or bath, especially marked "dishes," should be provided for the washing up of such utensils, and used for no other purpose. Clean cloths only should be employed for washing

utensils in the bath, which must be well supplied with hot water from the cook-house. All the cloths used for this purpose should be washed out daily, and hung to dry on the scullery table; each cloth being marked "dish-cloth" in large letters. For the scouring of tea-cans, meat-dishes, knives and forks, clean bath-brick shaken in from a tin kept for the purpose should only be used. The use of casually collected sand must be forbidden for this scouring work. The scullery table should be inspected daily by the orderly officer and, if possible, provided with a conveniently placed sink with hot and cold water. The carrying out of these details will be facilitated by the issue of an "order board," signed by the adjutant, to the permanent sanitary orderly of the squadron, company, or section, whose especial duty should be to superintend the cleaning by cleanly means of everything used by the men at their meals.

Latrine accommodation in barracks is provided for single non-commissioned officers and men at the rate of 5 per cent.; the same ratio holds good for urine stalls. When dry earth closets are used the provision of seats is at the rate of 7 per cent. In most barracks at home water carriage of sewage is available: the type of closet is of a very simple nature, and the flushing either done automatically or by hand every three hours. In some of the newer barracks ordinary water-closets with individual flush tanks are provided. Much has yet to be done towards getting the men to use these water-closets properly and intelligently. This end will not be attained unless regimental officers themselves display a personal interest in the matter. It is no use handing over this detail to the quartermaster and his staff; each

latrine should be visited and inspected daily by the orderly officer of the day, and any misuse made the subject of disciplinary measures. In many units this is done, with the very best results and no loss of dignity. The usual location for closets and urinals for single men's barracks is in a detached block conveniently situated for ready access from the barrack rooms. For some types of barrack block the closets are placed in the centre of the building, near the head of the staircase. For night convenience the almost universal arrangement in barracks is the placing of a urine-tub immediately outside each room ; this tub is removed in the early morning. Too often this urine-tub is made of wood ; it should be of metal, and provided with handles. In the newer barracks this objectionable feature is being obviated by the provision of fixed urinals of conventional pattern on the stairway landings ; these urinals are only used at night, being kept locked during the day. The dry earth closet exists in a few barracks at home, and is found to work well, the usual arrangement being the provision of a pail or portable midden placed under apertures in a well-fitted seat, with boxes of dry earth from which, by means of a scoop, the user covers the excreta over. As many soldiers are familiar with this system before they enlist, less difficulty is experienced in getting them to use these places properly than is the case with the water-closets. The pail contents are removed daily. This work is done usually by a civil contractor, the ultimate disposal of the material not being within the purview or responsibilities of the military officials. Less danger attaches to the ultimate disposal of this material in

military life than to careless management of the original place of deposit—that is, the latrine itself. If the closets and latrines are carelessly supervised, mischief is sure to result; they become foul and centres of infection at the very doors of the men's barracks. No matter whether it be a water or a dry earth closet, all woodwork and fittings must be kept scrupulously clean. The seats should be scrubbed daily with soap and water, the scrubbing to embrace both upper and under surfaces of the seat. The pans or pails must be kept clean, and no collection of filth allowed to remain exposed or uncovered with either water or earth. Where earth closets are in use the proper employment of the earth must be enforced, with an adequate supply of finely powdered dry soil and a sufficiency of scoops. The pails must be of a size to fit closely under the seat. There should be no gap or space between the top of the pail and the seat; if there is, it means certain fouling of the floor with urine or other matter. The latrine floor must be suitably sloped, and of some hard, impermeable material. A sufficiency of pails must be available, so as to allow of those which have been fouled being cleaned and sweetened. This will be best secured by first washing out the contents with water, drying and airing by exposure for a few hours to the sun if possible, and then swabbing over of the inner surface with the heavy cresol oil supplied by the barrack department. The coating of these utensils with tar is to be discouraged, as being unsightly and tending to conceal rather than remove dirt. The contents of each pail should be transferred without spilling to a suitably covered water- and air-tight receptacle for

daily removal. Urinals need to be managed on similar lines. The slabs of slate or glazed earthenware should be adequately flushed with water, and twice a week swabbed over with the heavy cresol oil supplied for the purpose. This does not need to be applied in excess; just sufficient to impart a greasy surface is ample. The care of these places should be the duty of the regimental sanitary squad. Well-managed latrines and urinals should be devoid of smell and free from flies, even in warm weather.

Tropical Barracks.—The preceding types of barrack are all designed for home or temperate climates. In tropical countries the essential principles for similar buildings are the same, the main difference between the two being that the walls and roofs are thicker, coupled with the provision of a wide verandah running all round the building. The general style of tropical barracks may be described as long, thin, somewhat narrow lines of buildings arranged *en échelon*, with thorough cross-ventilation and high plinths. The new barracks in India are for the most part of a single storey, but many of the older ones are two-storeyed. The number of men in a room never exceeds twenty-four, each man getting in the plains of India 90 ft. of floor space and 1800 cubic ft.; in Indian hill stations the allowance is as at home. In foreign garrisons other than India the floor space varies from 60 to 80 sq. ft., and the cubic space from 630 to 1000 ft. Few of the barracks abroad are provided with dining-halls, the men usually eating their meals either in the rooms or on the verandahs. In the tropics the kitchens need to be protected from flies by means of wire gauze to

all windows and doors. It would further be a step towards better sanitation if, in India and our other tropical garrisons, the multiplication of small company cook-houses were abolished, and a single large cook-house and proper dining-hall provided in all barracks. Until this is done the chances of food pollution are unnecessarily multiplied.

In tropical and sub-tropical climates, if barracks are not made too broad, and are properly placed, the same principles of ventilation may be applied to them as to barracks at home. The perflation of the wind should be obtained as freely as possible. The numerous doors and windows, however, render it unnecessary to provide special inlets. Outlets should, as at home, be at the top of the room, either along the ridge, or, if of shafts, they should be carried up some distance; if they are made of masonry, and painted black, the sun's rays will cause a good up-current. The area of the shafts is ordered to be 1 sq. in. to every 15 or 20 cubic ft., with louvres above and inverted louvres below. In the lower rooms these shafts are built in the walls, while in the upper rooms they are placed in the centre of the ceiling. In many tropical countries, at certain seasons, the air is both hot and stagnant; in such stations artificial ventilation must be employed, and the forcing in of air offers greater advantages than the method by aspiration. The wheel of Desaguliers was introduced into India many years ago by Rankine, and, under the name of "Thermantidote," is frequently used in private houses and military buildings. The great advantage of it is that the air is put not only in motion, but can be cooled by being forced through wet

grass mats suspended in a short discharge tube. The common fan or punkah acts too as a ventilator, as it displaces masses of air; but its value in this respect is probably small.

In India and most of our foreign garrisons water carriage of sewage is practically unknown, the dry earth system being almost universal. For many years this system has been considered to be admirably adapted for tropical needs, and from a purely administrative point of view so it is. But the considerable incidence of enteric fever in garrisons where this conservancy method is in force, coupled with a more accurate knowledge of the vitality and fate of the enteric bacillus in soil, has caused doubts to arise among experienced Army medical officers whether the dry earth midden or pail, however successful at home and in a moist climate, is altogether an unmixed blessing in hot and dry climates. We confess to be ourselves among those who distrust the efficiency of a dry system of barrack latrines in arid and tropical countries. If we could ensure the method being carried out perfectly, many of the objections to it would disappear; but we cannot ensure perfection in details which are essential. The first difficulty arises with the soldier himself; he often fails to cover his excreta *completely* with earth. At home or in a temperate climate this matters little, except in the hottest season, but in a tropical or subtropical country, where flies are present everywhere in enormous numbers, the slightest failure to secure absolute and complete covering of the excrement with earth means the inevitable dissemination of this objectionable matter by these insects back to man and

his food. The next difficulty arises from careless handling, removal, and disposal of the material by the scavengers deputed to perform this work. In nine cases out of ten this means native labour, and in a tropical country complete supervision is often impossible. The pail contents are transferred to iron receptacles with close-fitting lids, from which they are daily emptied into special tank carts for transfer to and burial in land allocated for the purpose. The possibilities of mishap in the course of these necessary manipulations are many, the result being that offensive material is spilled about or exposed to flies and other saprophytic creatures, who bring it back to man's immediate vicinity. Again, the final disposal on or into land in a tropical country is full of fallacies. The only safe mode of disposal is deep burial; in practice this can be done rarely. The ordinary procedure is superficial burial in or on the soil. In arid districts this means rapid desiccation, pulverisation and prompt disposal by the first wind that blows; and in times of dust storm this means translation for miles. Lastly, there is the difficulty of supplying to the latrine dry earth which is not itself excrement-tainted. Too often such earth is soil brought back from land where excrement was disposed recently. To sterilise it before issue is impracticable; therefore the average dry earth latrine in a tropical country becomes in too many cases nothing but a centre of infection, the air of which is laden with excrement-tainted dust and infected with flies, the bearers of equally disease-giving matter.

To those familiar with the conditions prevailing in many of our Indian garrisons this is no overdrawn

picture. The difficulty is how to find a remedy. Some advocate a more thorough supervision and closer attention to detail; this has been tried and found wanting. Others suggest and have tried burning, but a very short experience of attempting to burn large volumes of excreta and earth will demonstrate the futility of that method for general use. Any system of water carriage on the lines of our home practice is equally impracticable, as there is not the necessary water. There appear to be three possible substitutes for the existing dry earth system, consistent with the ordinary conditions of our tropical garrisons and barracks. One is to change the whole rationale of the latrines and convert them from dry to moist. This could be done by locating above each pail or midden a small tank containing water with or without some antiseptic deodorant. Each user would be called upon to release or discharge from this tank a certain quantity of the liquid, so as to cover the excrement. The pail contents would be removed in the usual way by hand, and disposed on land. We are not aware of this method having been tried; it would get rid of the dry earth, with its attendant dust-laden air, in the latrines, and would serve to cover up the excrement from the attacks of flies. The objections to its application centre mainly in the expense of providing the necessary tank fittings and the water, medicated or otherwise. That it would be an improvement on the present dry installation is certain, and as a possible arrangement in some places is worth bearing in mind.

The second proposal involves the retention of earth in the latrines, but using it in a moist state, the moisten-

ing being done by means of water or crude mineral oil. The latter is preferable, as it limits inducements for mosquito-breeding, and, too, would be inimical to flies settling on or about the excretal material. The subsequent handling and disposal of the night-soil would be the same as in an ordinary dry earth latrine. We believe this method has been tried in India and found to work well. The main difficulty is the expense of providing the mineral oil; but if only the lowest grade oil be used the cost should not be prohibitive. The admixture of an inflammable oil with the earth and excrement would facilitate any attempt at incineration, if tried. We should like to see this form of moist earth latrine given a full trial.

The third alternative is to discard the addition of any deodorant or covering material to the excreta deposited in the pails, but to have the contents of each pail transferred as soon as possible to a closed metal tank, in which, once a day, the contents are subjected to a temperature of 180° F. for a few minutes by means of a fire located under it. This secures practical destruction of such germs as those of enteric fever, dysentery, or cholera, if present; after which this presumably non-pathogenic fæcal material is carried away in covered carts to be placed on land. This method is said to have given good results in certain Indian garrisons where it has been tried. We hope that experiments on one or other of these lines will be persisted in, and that the prevalent dry earth latrine will soon become a sanitary curiosity in our tropical garrisons, just as the old pan-closet has become in this country.

Whatever form the latrine may take, it is desirable

that a double set of pails be provided, so that the same pan is not in use on two consecutive days. On the off day the pan, after being well cleaned out with kerosene oil and some crude phenol, should be left exposed to the air. All the seats should be washed daily with soft soap and water, and then both surfaces brushed over with kerosene oil. Finally, any loose soil on the floor should be watered twice a week with kerosene oil, well rammed down, and on no account be brushed or swept. All scraps must be removed by hand. So far as possible, the latrine should be regarded as a company or squadron institution, and men be taught to use only their own company or squadron latrine. These measures will be found to prevent flies haunting the latrines, and serve to localise any chance of infection.

As regards the final disposal of the excrement, there are two essentials. These are: (1) Let the removal be done always in daylight, when adequate supervision can be imposed; (2) never dispose of this material by superficial burial; let the excrement be buried at least one foot deep, not more, and see that it is covered with fine earth, not earth in lumps or clods; if this be done, we reduce the chances of these areas becoming breeding-places for flies.

Huts.—Of late years the use of hut barracks, both in peace and war, has increased in our army. In peace their first cost is small, and they are healthy. In war-time they afford the means of housing an army expeditiously, and are better adapted for winter quarters than tents.

The ground occupied by a hut should be cleared, levelled, and drained. The hut should be provided

with ridge ventilation, and projecting eaves to carry off the rain-water from the foundations; it should have the requisite number of windows, and should be raised sufficiently above the ground to allow a free current of air to pass underneath the flooring. In hot climates the roof and sides should be double, if these latter are not protected from the sun by verandahs. Like permanent barracks, they are best placed *en échelon*, to receive the full advantage of winds. Their ventilation is effected by openings in the ridge; or outlet shafts may be used, passing through the roof and terminating in louvres, with inlets under the eaves. Warming may be effected by the use of stoves or an open grate; the latter is preferable, as it assists in ventilation. At home stations where hutments are in use the floor space per man is 50 sq. ft., and the cubic space 500 cubic ft.; at stations abroad the floor area per man varies between 50 and 70 sq. ft., and the cubic space between 500 and 850 cubic ft.

The construction of huts depends on whether they are used for temporary purposes or whether they are intended to be of a more or less permanent character. In the latter case the sides are built usually of brick. What are known as Döcker huts have been favourably reported on and much used both in our own and the German army. They are made of wooden or iron frames, covered with a kind of felt, and lined with canvas. They are very portable, and the fastenings are so arranged that they can be put together in a very short time. These huts are well ventilated by windows, cross louvres, and ridge ventilators; if so desired, they can be readily warmed.

In addition to these, there are a variety of other huts differing from each other only in the nature of the material of which they are constructed. In general design and type they are similar. As a rule huts should not be made to accommodate more than twenty-four men.

Married Quarters.—In all barracks an important detail is the provision of suitable married quarters. In the older type of barrack the only quarters provided for married soldiers consisted of single rooms arranged four on a floor, two on either side of a central gangway or staircase, on two or three floors. The next development or concession to decency was the three-roomed quarter, consisting of a living room, bedroom, and scullery. A few of these are still to be found in existing barracks. Later followed what are known as the barrack attic and the dépôt type of married quarter, in which differences were made in the number of rooms and the style of their finish for allotment according to the rank of the occupant. Up to this period domestic conveniences were entirely detached from the quarters. The next stage of development was the verandah type, in which these conveniences were arranged at the ends of the blocks, and at the same time the common-sense system was introduced of allotting the different-sized quarters according to the number of a soldier's family instead of according to his rank. On this basis all quarters for married soldiers were reduced to three classes, namely, "A," "B," and "C," without distinction as to finish or rank of the occupier. The "A" quarter has one bedroom, the "B" quarter has two bedrooms, and the "C" quarter has three bedrooms, in addition

to, in all cases, a living room and scullery. In the latest types, as represented by the self-contained attic and self-contained verandah quarters, a separate water-closet is given to every quarter. A still later type of quarter is a modern adaptation of the old dépôt variety, in which the quarters, consisting of living room, scullery, and two bedrooms, with water-closet, are all alike and two-storeyed. Each pair of quarters is so arranged that by throwing one bedroom of any quarter into the next we get a three- and a five-roomed quarter, *i.e.*, an "A" and "C" quarter in place of two "B's." These are comfortable working men's quarters without being luxurious, and the design constitutes a notable approximation of the military requirement to that of the corresponding social class in civil life.

In tropical garrisons the married people's quarters are grouped usually in one-storeyed blocks, each block holding the married people of a company or troop. Two to three rooms only are provided for each family; but as the quarters embrace verandahs, 12 and 10 ft. wide, at front and back, supplementary accommodation is readily arranged, if required.

CHAPTER IX

WATER-SUPPLIES

In military life this question presents certain special features, but in respect of general principles it differs little from the corresponding problem in civil life. In both communities the supply of wholesome water in sufficient quantity is a fundamental sanitary necessity. Without it, injury to health arises invariably, either simply from deficiency of quantity, or more frequently from the presence of impurities.

Water is a chemical compound, consisting of two volumes of hydrogen and one of oxygen, being formed whenever hydrogen gas or a combustible substance containing hydrogen is burnt in oxygen or atmospheric air. At the ordinary temperature of the air pure water is a clear, colourless, tasteless, and odourless liquid. At a temperature of 0° C., or 32° F., water becomes solid, or freezes, expanding during the act of freezing nearly one-eleventh of its volume. Water having its greatest density at 4° C., or 39° F., it follows that this solid water, or ice, always floats. At 60° F. 1 gallon of water weighs 10 lb., while 6·23 gallons occupy 1 cubic ft. of space. Water possesses a certain amount of elasticity and compressibility, this characteristic increasing as the temperature rises. It has a high capacity for

heat, but is a bad conductor of heat. Water evaporates at all temperatures, even when in contact with atmospheric air or other gas, and the vapour given off has a density and tension determined by the temperature. The most remarkable feature of water is its power of dissolving substances. It dissolves or retains all known gases, and there are only a few solid substances that do not yield gradually to the solvent action of water, assisted as this is by the gases present in all natural waters. The solubility of different substances is, however, very unequal. Generally the solubility of any particular body is increased in proportion as the temperature is raised; but there are exceptions to this rule; for example, water at 32° F. dissolves nearly twice as much lime as water at 212° F. In the case of gases the amount which water can dissolve is dependent largely upon the pressure, and under ordinary pressure it is generally larger in proportion as the temperature is lower. The aqueous solutions of solid substances and of certain liquids and gases have a higher density than ordinary water. The freezing point of watery solutions is lower than that of water. Thus, sea-water, which is largely a solution of various salts of magnesium, potassium, and sodium, freezes less readily than fresh water. The boiling point of water is raised when it contains solid substances in solution.

Amount of Water Required.—In estimating the quantity of water required daily for each person it is necessary to allow a liberal quantity. There must be avoidance of waste, but still any error in supply had far better be on the side of excess. In civil communities

the daily allowance per head of population varies immensely, but includes water for municipal and trade purposes. The following are the gross amounts used in some typical communities, for all purposes, in gallons per day: London, 35; Liverpool, 31; Manchester, 29; Edinburgh, 38; Glasgow, 58; Sheffield, 25; Leeds, 34; Swansea, 36; Bristol, 22; and Leicester, 17. In the Army 20 gallons per day are allowed for each adult and 10 gallons for every child.*

Taking all sexes and ages together, we may lay down the minimum necessary for drinking and cooking purposes as 1 gallon per head per diem. For ordinary personal washing it is permissible to reckon 3 gallons will be needed, while for washing of clothes, utensils, and general cleaning another 3 gallons will be required daily for each person. Therefore, without baths and water-closets, we may say 7 gallons per head daily will be the usual minimum need; while with baths quite 11 gallons should be allowed. To meet the requirements of water-closets 6 more gallons will be necessary; and adding 3 gallons for unavoidable waste we get 20 gallons daily per head as the average requirement of a mixed community. This agrees with the official issue in the service. For town and trade purposes, including animals, it is usual to add another 12 gallons, making 32 gallons in all. In the Army 20 gallons are allowed daily for each horse during peace. This figure makes the official allowance of water approximate for all purposes to the corresponding issue in civil life. For soldiers living in camps these figures need to be considerably modified. Under circumstances of

* "King's Regulations," 1908, para. 1037.

stress 1 gallon daily per head might suffice; including animals, the minimum allowance may be put at 3 gallons per head each day. As a general statement, a daily allowance of 5 gallons per man may be taken as the usual water requirements in camp, with at least as much again for each horse or camel. Apart from the difficulties experienced in supplying more, it is desirable not to exceed this amount in camps, as any excess means waste, with corresponding difficulties in surface drainage and avoidance of sloppiness.

Sources of Water-Supply

The constant evaporation which takes place from the surface of all masses of water exposed to the atmosphere, the diffusion of water vapour throughout the atmosphere, and its subsequent condensation there to the liquid or solid state, give rise to the circulation of water which is continually taking place. Of this condensed atmospheric vapour, falling on the surface of the various continents and islands, part penetrates into the soil until it reaches a less permeable stratum, above which it accumulates, part flows away and becomes the source of the great rivers and lakes, some is absorbed by the soil itself, while the remainder passes off in vapour, to be again condensed in the form of either rain, snow, hail, dew, or mist. Viewed in this manner, this condensed water from the atmosphere is the primary source of all our water-supplies. These, again, resolve themselves practically into either (1) rain, pure and simple; (2) water derived from melted snow or ice; (3) water collected on the surface of the ground

in the form of ponds, lakes (upland surface water), streams, or rivers; (4) so-called ground water, or that which has percolated to varying depths into the soil, and reaching the surface again either by means of springs or wells. Supplementary to these four chief sources of drinking water may be mentioned sea-water and distilled water. Each class of supply has its own peculiar characteristics, and demands special consideration.

Rain-water approaches nearer to absolute purity than any other kind of natural water. When collected in clean vessels it contains only such dissolved substances as it can take up from the atmosphere. As it falls through the air it becomes highly aerated, but in inland districts the amount of impurities which rain absorbs from the air is often considerable. It is, however, mainly from the surfaces on which rain falls that the chief impurities result. These consist generally of bird-droppings, decayed leaves, soot, and such matters as collect on roofs, platforms, in gutters and receiving vessels. For these reasons rain-water, as ordinarily collected and met with, is an impure and dirty water, and its use as a supply for drinking purposes only justified in places where no better source is available. The chief merit of rain-water is its softness, owing to the absence of salts of lime and magnesia. On this account it is good for washing or cooking purposes, although this very attribute of softness renders it less palatable than other kinds of water for drinking. Owing to its aeration and richness in dissolved air, rain-water has frequently a considerable erosive action on lead. This is a feature of some importance in con-

nection with pipes, fittings, and cisterns or tanks to be used for its storage.

Apart from these drawbacks, rain as a general source of water-supply for domestic purposes is unsatisfactory, owing to the uncertainty of the rainfall from year to year, the length of the dry season in many countries, and the large size of the reservoirs which are then required.

The *amount* of water given by rain can be easily calculated if two points are known, viz., the amount of rainfall and the area of the receiving surface. The rainfall can only be determined by a rain-gauge; the area of the receiving surface must be measured.

The following formula is the one generally used:

$$\frac{\text{Area in square feet} \times 144 \times \text{rainfall in inches}}{1728} = \text{cubic feet.}$$

To calculate the receiving surface of the roof of a house we must not take into account the slope of the roof, but merely ascertain the area of the flat space actually covered by the roof. The joint areas of the ground-floor rooms will be something less than the area of the roof, which also covers the thickness of the walls and the eaves.

In most English towns the amount of roof space for each person cannot be estimated higher than 60 sq. ft., and in some poor districts is much less. Taking the rainfall in all England at 30 ins., and assuming that all is saved, and that there is no loss from evaporation, the receiving surface for each person would give 935 gallons, or $2\frac{1}{2}$ gallons a day. But as few town houses have any reservoirs, this quantity runs in great part to waste in urban districts. In the country it is an important source of supply, being stored in cisterns

or water-butts. If, instead of the roof of a house, the receiving surface be a piece of land, the amount may be calculated in the same way. It must be understood, however, that this is the total amount reaching the ground. All of this will not be available; some will sink into the ground, and some will evaporate. The quantity lost in this way will vary with the soil and the season from one-half to seven-eighths.

One inch of rain delivers 4·673 gallons on every square yard, or 22,617 gallons (101 tons by weight) on each acre. Inches of rainfall $\times$ $14\frac{1}{2}$ = millions of gallons per square mile.

The extent and value of any given tract of country as a catchment area for water can be determined only by a study of properly prepared maps. The importance of the contour lines in the map of any given district as indicating its value as a watershed or catchment area will be manifest, as these lines separate drainage areas, and form, therefore, the boundary of catchment basins. In estimating the annual yield of water from rainfall, and the yield at any one time, we ought to know the greatest annual rainfall, the least, the average, the period of year when it falls, and the length of the rainless season. The average of twenty years *less* one-third gives approximately the rain in the driest year, and the same average *plus* one-third gives very nearly the amount in the wettest year. The average of the three driest years in twenty is a safe basis. It may be assumed that on the average six-tenths of the rainfall is available for storage. It must also be remembered that the amount of rainfall differs very greatly even in places near together.

The utility of **ice- and snow-water** is obviously very limited; moreover, its use is not free from danger, especially in the case of ice derived from polluted water. The mere act of freezing appears to have a relatively feeble effect in destroying bacteria, and on this account because water has been frozen it cannot be deemed necessarily safe. In its general qualities water derived from dew or melted snow may be regarded as similar to ordinary rain.

Surface-waters.—Rain falling on to the surface of the earth and remaining there is available in the various forms of puddles, pools, ponds, lakes (upland surface-waters), ditches, streams, and rivers. Surface-water running off uplands or hills may be clean or dirty, according to the nature of the land or country over which it flows. Such water running off hills over which neither man nor animal goes will naturally be cleaner than similar water flowing over manured land or over country which men and animals frequent. The same must be said of other surface-waters in pools, lakes, ditches, and streams or rivers. Sometimes this water will be clean, sometimes not, according to the nature of the banks and neighbouring country, and according to what opportunities exist for the filth of man and animals to gain access to it. As a rule it may be assumed that water obtained from these sources is unclean. There are, of course, exceptions, and each case must be judged on its merits, as disclosed by a scrutiny of local conditions. Many communities obtain safe water from upland surface supplies, but the gathering grounds are usually well safeguarded from casual pollution by adequate patrolling. Rivers are fed from

such a variety of sources that the quality of the water they yield is extremely variable. A stream running through a sparsely occupied district will obviously be cleaner than one passing through a more densely populated area. Equally facts as to local methods of sewage disposal will materially affect the opinion to be formed as to the probable quality of water yielded by a pool, pond, stream, or river. The rule should be, *regard all surface-waters with suspicion.*

In connection with sources of water-supply from streams and rivers there arises often the question of yield. The rough average yield of a stream may be measured as follows: Select some fifteen yards of the stream where the channel is fairly uniform and free from eddies. Take the breadth and average depth in feet at three places. Drop in a chip of wood, and find the time it takes to travel say thirty feet. The surface velocity of the current can then be calculated in feet per second. Four-fifths of this will give the mean velocity, and this multiplied by the sectional area will give the yield per second in cubic feet of water. In the case of small streams the following method may be adopted: Get a plank and cut a triangular notch in it, with sides at 90 degrees. Dam up the stream so that it is nearly at rest behind the dam and flows away through the notch. Measure the height from the bottom of the notch to the surface of the water where it is not affected by the overfall. The discharge in gallons per minute can be calculated from the following formula: $1{\cdot}978\ H^2\sqrt{H}$, where H is depth of water above apex of notch in inches. If in place of cutting a V-shaped notch a rectangular notch or slot

be cut, the formula $6{\cdot}23\ \sqrt{H^3 \times 0{\cdot}402}$ gives the flow in gallons per minute.

Ground-water.—Under this term is indicated the vast volume of water which exists at varying depths below the earth's surface, representing the water which, having fallen as rain, has soaked or percolated through the soil layers. The amount of, and facility of access to, water underground varies with the configuration and density of the earth's crust. In some places it may be abundant at a depth of only a few feet, while elsewhere it may be scanty or only obtainable at considerable depths. Man gains access to this ground water either by springs or wells.

Springs are natural outcrops or overflows of the underground water. The rain which falls on a permeable soil percolates downward until it is arrested by a bed of clay or other impermeable stratum, and there becomes stored underground until it rises to a point or level at which it can appear spontaneously at the surface. Springs are found commonly on the side or foot of a hill, in valleys, and near the beds of rivers. The water obtained from springs is usually good, though often hard and loaded with mineral salts, such as lime, which have been dissolved out of the soil. Spring-water is clear and bright, in consequence of the great degree of filtration which it naturally undergoes, in percolating through the soil layers, between the gathering ground and the point from which it issues again from the earth. Spring-water is both pure and impure in different cases, and the mere fact of water being derived from a spring is not necessarily a guarantee of its goodness, though in the majority of cases it may be regarded as safe.

The yield of a spring is determined most readily by receiving the water into a vessel of known capacity and timing the rate of filling. The spring should have been opened up previously, and the receptacle employed should be of large size. In cases where a spring yields a steady but small volume of water an increased supply may be frequently obtained by digging out the spring-head. The chief risk attaching to springs is the facility of pollution of the issuing water by surface washings;

FIG. 11.

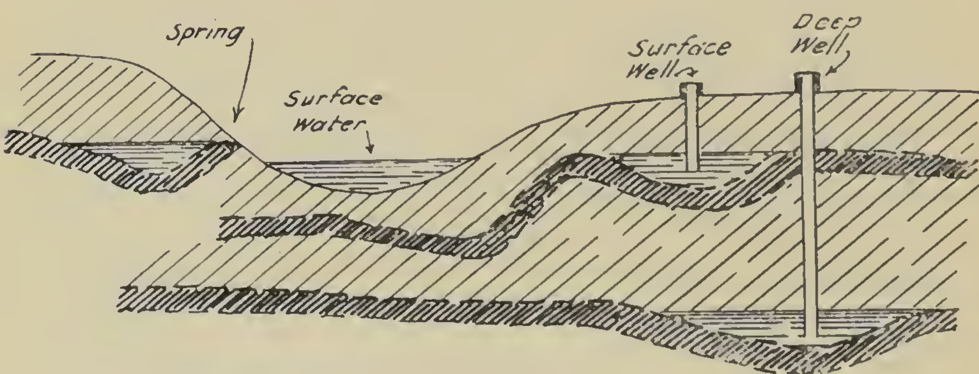


Diagram illustrating some common sources of water.

hence, when used for any length of time a spring should be enclosed, its level raised, and the ground made to slope away from rather than toward it. If this is impracticable the vicinity should be so ditched that all surface drainage from higher ground is intercepted and conducted to a point below the level of the spring.

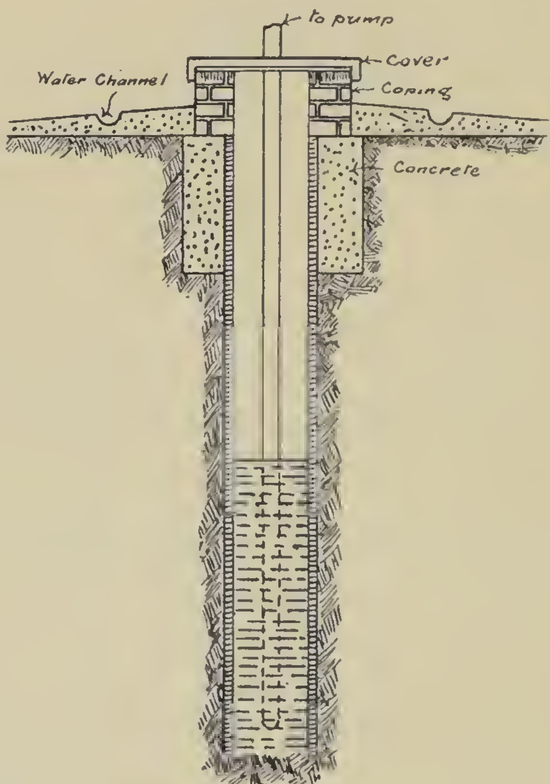
Wells may be divided into two classes, shallow and deep; in both cases they represent shafts or borings sunk by man to tap or gain access to the underground water. Shallow wells draw their water-supply from the

subsoil, while deep wells tap the water-bearing layer beneath some impervious soil stratum which separates it from the subsoil above. By far the larger number of wells met with belong to the first class. Shallow wells may yield good water provided there is no risk of pollution from surface washings or from their proximity to cesspools or leaky drains. In or near towns, villages, or farmyards this pollution is very liable to occur, so much so that water from shallow wells, say from ten to fifty feet deep, is always to be regarded with suspicion. The distance drained by wells is undetermined, the area varying with the nature and purity of the soil, but in the majority of cases the radius of the area drained is equal to four times the depth at least, and may even exceed this. A porous soil with no impervious superficial stratum will admit of impurities reaching a well from the surface which a clay soil would shut off. The movement and course of the ground-water being in the direction of the nearest watercourse or the sea, to protect the water-supply from any soakage from leaky drains or cesspools in the vicinity a well should be placed above all such possible sources of contamination. A well which yields a moderate quantity of good water may, if the demand on it be increased, draw in water from the surrounding parts, and thus tap sources of impurity which a moderate demand left untouched. A sudden rise in the ground-water may also lead to direct communication between a cesspool and a well, by the water tapping the former in its flow.

In some cases a well at a lower level may receive the drainage of surrounding hills flowing down to it from great distances. Good coping-stones, so as to protect

from surface washings, and good masonry for several feet below the surface of wells in very loose soils, so as to prevent superficial soakage, are necessary in all shallow wells. In the majority of cases where shallow

FIG. 12.



Well, suitably protected.

wells yield polluted water this is due to defects in their construction. The accompanying figure (Fig. 12) indicates a simple plan for the construction of such wells, and constitutes a type which it is desirable that builders and others should follow. The growth of trees should not be encouraged in the immediate vicinity of wells, as their roots are apt to cause facilities for the inlet

of surface-water. For similar reasons moles and rats should be prevented from burrowing near wells.

Deep wells, artesian and tube wells are generally of great depth, passing through an impermeable stratum, such as clay or rock, and penetrating a water-bearing soil which crops up elsewhere at some higher point, and below which again is another impermeable stratum. From the nature of these facts it is easy to understand that the water from these deep wells or borings is nearly always good. Like the shallow wells, these must be adequately protected at the surface to avoid pollution at that point.

The use of distilled water needs a short reference, as it is one of the most effectual modes of freeing water from all its impurities. On board ships distillation of sea-water is resorted to in order to render salt water fit for drinking; and although the water thus obtained is pure, yet, all the gases having been driven from it by the boiling, it is unpalatable, and by some supposed to be indigestible. It may be aerated by allowing it to trickle slowly down through a long column of wood charcoal, or by filtration through some porous substance. In all distillation apparatus care needs to be taken that the distilled water is not left in contact with lead, zinc, or copper fittings, as the water has a curious ability to dissolve and attack these metals.

Hard and Soft Waters.—Water is frequently described as being either *hard* or *soft*. Hardness is due to the presence in the water of the salts of lime and magnesia. If the hardness is due to carbonates of these earths, and if its amount is not excessive, it renders a water palatable and does not interfere with

its wholesomeness; but if, on the other hand, it is caused by the sulphates of lime and magnesia it is objectionable. The hardness due to the carbonates is largely removable by boiling, but that due to sulphates is unaffected by boiling. Hard waters are wasteful, as in washing much soap is expended before a permanent lather is obtained. Vegetables boiled in such water are difficult to digest. The difficulty of infusing tea with hard water is well known.

Comparative Qualities of Water-Supplies.—This depends on many circumstances. Rain-water, if properly collected and stored, affords an excellent supply when other sources are not available, especially in country or sparsely populated areas. In towns, rain takes up such impurities from the air and from the various collecting surfaces that it cannot be looked upon as satisfactory. The uncertainty of the supply and the length of the dry season necessitates often a large storage capacity, which is not desirable. Rain-water should be filtered or clarified to remove suspended matters before being stored, and the tanks protected from light and heat. Spring-water is both pure and impure in different cases, and the mere fact of its being a spring is not, as sometimes imagined, an index of goodness. Much depends upon the geological formation and how well the spring is protected from surface pollution. When springs arise from sand or gravel the immediate neighbourhood needs careful scrutiny; as a rule, from five to ten acres above and around a spring should be free from all manurial matter, and that portion of the area immediately affecting the spring should be enclosed to prevent the access of men

and cattle. If heavy rainfall renders a spring-water turbid, it is highly suggestive that the source is unsatisfactory. Shallow-well water is always to be viewed with suspicion; the same must be said of most river-water, as a river is the natural point to which the drainage of a good deal of surrounding land tends, and heavy rains will often wash many substances into it. Apart from this, few rivers are free from the discharge into them of much objectionable matter, if not actual sewage. Upland surface-waters are, as a rule, safe, but much depends upon the presence or absence of habitations, flocks or herds of animals, and adequate policing of the collecting area.

The comparative merits of these various sources of water-supply may be stated thus:

Wholesome	1. Spring-water . .	very palatable.
	2. Deep-well water . .	
Suspicious	3. Upland surface-water .	moderately palatable.
	4. Stored rain-water .	
	5. Surface-water from cultivated land	palatable.
Dangerous	6. River-water, to which sewage gains access	
	7. Shallow-well water . . .	

Storage and Delivery

The methods of storing and delivering water will vary with its source. In upland surface schemes, storage reservoirs are a necessity to equalise the supply and demand; they are usually made by impounding the water from the gathering grounds in such a position that the community may be supplied by gravitation. Compensating and service reservoirs are also necessary: the former to receive the turbid water at flood-time, so that the compensation water to be given to streams and

mills shall not be a tax on the clear-water reservoir; the latter to receive the clear water and directly supply the command. The storage which is required in the impounding reservoir is usually from four to six months' supply. Reservoirs are placed on as high ground as possible, to give a sufficient head or pressure of water, so that every part of the cantonment may be supplied by gravitation; from thence the water is distributed by cast-iron pipes. Service reservoirs should be covered and ventilated; in form they should be deep rather than extended, as this lessens evaporation and secures coolness. Service reservoirs should only be filled with safe or purified water; this is especially called for where the supply is taken from surface-water. In the case of ground supplies obtained from deep wells it is usually only necessary to prevent the growth of fungi and other organisms in the reservoirs; this can be prevented by the exclusion of light. All reservoirs require periodical cleaning.

When water is obtained from a river the intake should be placed where a good stream is constantly flowing; stagnant and shallow parts must be avoided. The water is best taken 5 ft. below the lowest summer level, screens being placed so as to exclude grosser suspended materials. In river schemes it is usually deemed unnecessary to provide the large storage reservoirs required to equalise the supply and demand in gravitation schemes. It is sufficient if the smallest dry-weather flow of the river is so large as not to be seriously affected by the withdrawal of the amount required for the works. The water required is generally led from the river into subsiding reservoirs, where a

considerable amount of purification takes place; but even after sedimentation a river-water cannot be used for drinking purposes: it must be purified by sand filtration. The areas of subsiding reservoirs vary greatly, owing to differences of opinion as to the most economical point to carry the clarification before commencing filtration, but experience shows that the larger the storage reservoirs and the longer the water can be retained in them the greater is the self-purification obtained.

Occasionally rain-water collected from the roofs of buildings is the only available source of supply; great care should then be taken to ensure its freedom from metallic compounds and organic impurities. Rain-water must never be collected from lead surfaces, and even roofs covered with sheet zinc or galvanised iron give up zinc to water collected from them. After a drought the first water obtained contains many impurities. The storage of rain-water needs care, as it has an erosive and solvent action on lead. For this reason rain-water storage tanks are best made of slate or galvanised iron. They need to be well protected by covers, ventilated, and periodically cleaned out.*

Distribution.—When barracks are remote from sources of water the supply should be by aqueducts and pipes. The distribution by hand is crude and objectionable, for it is impossible to supply the proper quantity, and the risks of contamination are increased.

The supply of water to barracks may be on one of two systems, *intermittent* or *constant*. In the former the water is only turned on at intervals for a short time

* "King's Regulations," 1908, para. 1001.

during the day; in the latter the supply pipes are always kept full of water. The constant supply is the one usually aimed at, as no cisterns are required for storage, and the drinking water is taken direct from the main. When the supply is intermittent it is necessary to have cisterns in which to store a sufficient supply of water during the intervals when the water in the mains is turned off. The mains, being empty of water, are liable to be fouled by impurities from the soil, such as gas from leaky pipes lying in their vicinity, or actual sewage from a neighbouring leaky drain or sewer; the foul air, aided by the suction action of the pipe when the water is turned off, enters through any joint which may be faulty. Under proper supervision the waste of water is less on the constant system than on the intermittent system of supply. The great arguments against storage on the premises, except on a limited scale for closets and boilers or fire, are the chances of contamination in cisterns and the very imperfect means of storage.

Cisterns should always be well covered, protected as much as possible from both heat and light, and thoroughly ventilated if they are large. Care should always be taken that there is no chance of leakage into them. An occasional source of contamination is an overflow pipe passing direct into a soil pipe or drain, so that the sewer gases pass up, and, being confined by the cover of the cistern, are absorbed by the water. To prevent this the overflow pipe is curved so as to retain a little water and form a trap, but the water often evaporates, or the gases force their way through it. No overflow pipe should, therefore, open into a drain,

but should end *above* ground over a trapped grating. A cistern supplying a water-closet should not be used to supply cooking and drinking water, as the pipes leading to the closet often conduct closet air to the cistern. Hence a small cistern should be used for each closet. Cisterns should be periodically and carefully inspected; and in every new barrack, if they are placed at the top of the building, convenient means of access should be provided. Tanks to hold rain-water require constant inspection.

Water should be distributed not only to every barrack block, but to every floor in the building. If this is not done, in spite of redundancy of labour, cleanliness is liable to be sacrificed. In all water schemes the water must be conducted from the reservoirs or other sources of supply to barracks in pipes. The larger pipes are usually of cast iron; for the smaller pipes galvanised iron, lead, tin, or vitreous glazed iron pipes are used. Iron is the best material for all pipes of this nature; lead pipes should only be used when it has been proved that the water has no action on that metal. Soft waters are especially liable to act on lead. The action of water on iron pipes is often energetic at first, but diminishes after a little time.

Impurities of Water

The origin of the impurities of water may be referred to four heads, viz., substances derived from the source impurities added during transit from source to reservoir, impurities acquired during storage, and impurities the result of faulty distribution. The chief actual impurities may be classed into two kinds, viz., the mineral and the

organic; these latter may have either an animal or vegetable origin. The mineral impurities are in solution, while the organic are for the most part in suspension, as represented by disease-producing bacteria and ova of parasitic worms; some organic impurities, however, are in solution in water, existing as nitrogenous compounds or salts, the final products of the breaking down of vegetable and animal material derived from sewage gaining accidental access to the water. From the sanitary point of view more importance attaches to the suspended organic impurities than to those in solution, whether mineral or organic.

Impurities derived from the Source.—The geological formation of a district necessarily influences the composition of the water running through it, though it is impossible to tell with absolute certainty what the constituents of the water may be. The following soils generally yield a supply of pure water: granite, metamorphic and clay-slate soils, oolite, and chalk. Waters from the sands, sandstones, and gravels vary greatly in quality, and are uncertain sources of supply; the greensand waters are usually good, and in clean gravel, if not too near dwellings, the water is often free from impurities. The limestones commonly yield a pure water, but it is liable to be very hard. The chalk waters are, as a rule, wholesome and pleasant to drink; the main objection to this soil formation is its liability to fissures, by which impurities may be admitted to wells and springs without having undergone any process of percolation through the soil itself. Surface and shallow-well waters are commonly unsafe, unless taken from places which are remote from access by man or animals. Marsh-

waters are soft, but commonly contaminated with objectionable bacteria and other suspended matter; in tropical countries they should be studiously avoided. The chances of pollution of a deep well are small, provided it is properly constructed. Near the sea-coast, water from even deep wells may contain some considerable quantities of saline mineral matter. If excessive, the water will be unfit to drink.

Rain-water may be contaminated by washing the air it falls through, but more by matters on the surface on which it falls, such as decaying leaves, bird droppings, soot, or other matters on the roofs of houses; it also takes lead from lead coatings and pipes, and zinc from zinc roofs. If stored in underground tanks it may also receive soakings from the soil through leakage.

Impurities added during Transit from Source to Reservoir.—Open conduits are liable to be contaminated by surface washings carrying in finely divided clay, sand, chalk, and animal matters from cultivated land; and the leaves and branches of trees add their contingent of vegetable matters. These impurities may occur in most cases but, in addition, the refuse of houses, trades, and factories is often poured into rivers, and all sorts of matters are thus added. Associated with this material, and constituting its most dangerous elements, are innumerable bacteria, which, if derived from sewage, especially the effete material from diseases, such as enteric fever, dysentery, and cholera, are a certain and fertile source of water-borne disease.

During its flow in open conduits purification goes on by means of subsidence, by the action of the ordinary water bacteria on pathogenic micro-organisms, should these be

present in the water, by exposure to direct sunlight, and by the presence of water plants. It must be remembered that the natural habitat of disease-producing bacteria is the interior of the human body; when they pass from this into rivers they are in an unnatural medium, in which they can only maintain their existence and power of multiplication for a limited period, and tend rapidly to disappear under the conditions found in ordinary river-water.

Impurities of Storage.—The chance of substances getting into the water of wells and tanks, and even of cisterns in houses, is very great. Surface washings and soakings contaminate wells and tanks, and leakages from pipes, passage of foul air through pipes, or direct absorption of air by an uncovered surface of water introduce impurities into cisterns. It is singular in how many ways cistern- and tank-waters get foul, and what care is necessary, not only to place the cistern under safe conditions at first, but to examine it from time to time to detect contamination of the water. In India especially the tank-water is often contaminated by clothes washed near or actually in the tank; by the passage, even, of excrement directly into it, as well as by surface washings; so that, in fact, in some cases the village tank is one of the chief causes of the sickness of the people. There is perhaps no point on which the attention of the military officer should be more constantly fixed than that of the storage of water, either on the large or small scale.

Impurities of Distribution.—If water is distributed by hand, *i.e.*, by water-carts, barrels, or skins, there is necessarily a great chance of its being fouled.

In India, where the water is generally carried by water-carriers, inspection of the carts or skins should be systematically made, and whenever it be possible pipes should be substituted for the rude method of hand conveyance. But even pipes may contaminate water: metals (lead, zinc, and iron) may be partly dissolved; wood rots; and if the pipes are occasionally empty impure air may be drawn into them, and be afterwards absorbed by the water.

Effects of drinking Impure Water.—The diseases which are associated with the use of impure water are cholera, enteric fever, dysentery, diarrhœa, goitre, parasitic diseases, and some obscure forms of metallic poisoning. The virulence of a water-borne disease has some definite relation to the purity of the supply, for, once seeded with the specific germs, a polluted water appears to act more virulently than one that is pure. From our knowledge of the history of infective micro-organisms, it would appear doubtful whether they survive in good water for any lengthened period. Laboratory experiments show that from fourteen to forty days has been the maximum period of their vitality, and probably under less favourable conditions a much shorter period would complete their life.

The intimate association of both cholera and enteric fever with foul water is beyond dispute. In both diseases the specific germs gain access to the water by the discharges of those suffering from these diseases being allowed to enter defective drains, &c., the contents of which infect the subsoil water or are carried direct into rivers or streams from which drinking water is taken. That dysentery is caused by the drink-

ing of impure water there is ample evidence; in nearly every instance the water was polluted with fæcal or dysenteric discharges, and where the supply was discontinued the disease disappeared. It may also be said that water loaded with fine sand or mineral grit acts as a predisposing cause by exercising an irritative action on the bowels, as well as being directly the vehicle by which the specific germs are introduced into the body. Diarrhœa among soldiers has frequently been caused by the fine or gross suspended mineral matters in water. This affects the intestinal tract by mechanical irritation, and a bowel so damaged is consequently placed in an eminently receptive state for infection by various virulent germs should they be swallowed subsequently. The connection of goitre with various impure waters has long been suspected. At present we are doubtful on the point, but the weight of evidence certainly suggests that water is probably the cause. The question has no practical bearing on army sanitation. The ova of various parasitic intestinal worms are frequently found in water, particularly in the tropics; their presence and ingestion by man constitutes one of the channels of this kind of infection. Metallic poisoning may result from the absorption by water of the metal used in the making of service pipes, cisterns, &c. The water may be also contaminated at its source by passing through a soil in which a metal is present, as in some mining districts. Copper, lead, zinc, and arsenic are the most probable poisonous metals which may gain access to water in this way. As affecting the daily life of the soldier this is not a practical question.

Purification of Water

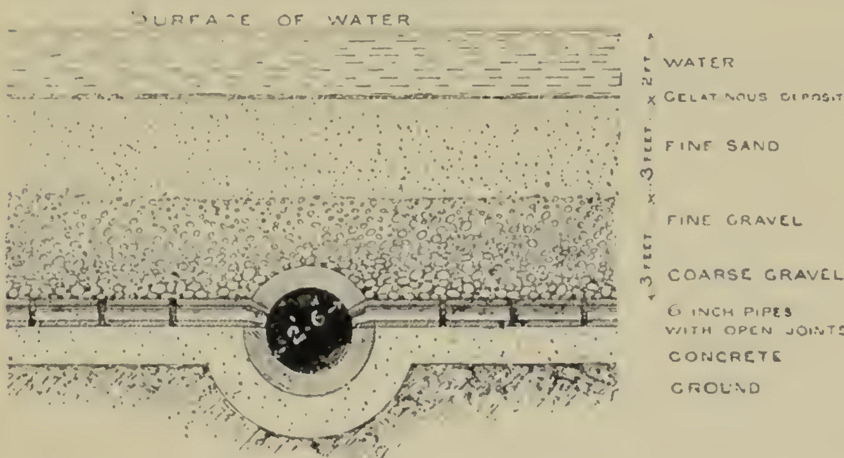
If it is realised what are the impurities likely to be met with in water, the principles on which and the practice by which they are to be removed will be readily understood. It may be accepted that we need not trouble about what is in solution, but aim simply to remove or render harmless that which is really suspended in water. This may be either coarse mineral grit, sand, and mud, which is more or less obvious to the naked eye, or it may be germs and similar living bodies, which, although floating and suspended in water, are so small that they are not to be seen by the unaided eye. A variety of procedures have been suggested and used for these purposes, and their applicability depends much upon whether it is intended to purify water in bulk or large volumes or whether the act of purification is to be applied to small quantities only. In civil life it is the exception rather than the rule for water to be purified in small quantities by the consumer, owing to the fact that water is nearly always submitted to some process of purification by the companies before distribution to the public. In military life it is rare to find any organised attempt made to purify water in bulk, but if it is of indifferent quality the act of purification is applied to relatively small quantities only. Among the methods suitable for dealing with water under one or other of these conditions may be mentioned those aiming primarily at removal of excessive hardness, various filtration processes, the employment of heat, and the addition of chemicals.

Removal of Hardness.—Certain waters, notably those from the chalk and magnesian formations, are rich in salts of the alkaline earths, such as calcium, magnesium, barium, &c. The presence of these salts renders a water "hard," and for economic reasons mainly it is necessary to remove these so-called hard salts, or, in other words, soften the water. Several methods have been used, bnt the basis of all of them is the addition of a measured quantity of milk of lime, calculated on the degree of hardness of the water. Carbonates of lime and magnesia constitute the main part of the hard salts of an ordinary water, and these are soluble in water containing free carbon dioxide. When a solution of fresh lime is added to such a water in proportion to the degree of hardness present, the lime combines with the excess of carbon dioxide to form carbonate of lime, which is precipitated with almost the whole of the carbonate of lime originally held in solution by the water, and falls as a sediment, carrying down with it the organic impurities held in suspension. This action of adding lime-water to remove the mineral matters (the salts of lime and magnesia) from a water is often spoken of as softening of water. The permanent hardness of a water is not tonched by this process; this hardness is due to the soluble salts of lime and magnesia held in solution by the solvent properties of the water itself. For the removal of this permanent hardness further treatment of the water is required, involving the addition of varying quantities of lime, sodium, or sodium carbonate.

Filtration.—Water is nearly always submitted to some process of filtration before distribution by a

public company, especially in England, where it is extremely difficult to obtain at its source a water which needs no purification. Filtration on a large scale is generally carried out as follows: A preliminary step consists in collecting the water into settling reservoirs, wherein the more bulky substances subside. The water is then filtered through beds of sand and gravel, containing perforated tubular drains below, into which the

Fig. 13.



SECTION OF SAND FILTER-BED

filtered water flows. The drains or pipes are covered by a bed of gravel some fifteen inches deep, over which is spread a layer of fine, clean sand about three feet deep (Fig. 13). Sharp, angular particles of sand are the best, and the gravel should increase gradually in its coarseness as it descends.

Experience shows that efficient filtration of water through sand and gravel beds cannot be obtained if the rate of flow exceeds four inches in the hour, or sixty gallons daily, per square foot of surface. As a rule 98 per cent. of the bacteria are removed from a water when so

filtered. The efficient working of these filters depends upon the formation of a slimy layer on the surface, and to some extent in the body of the filter-bed. This slimy layer, to which the greatest importance is attached, consists of zooglœa of bacteria combined with suspended materials in the water; it is extremely friable and readily broken by excessive pressure on the surface or disturbance of the body of the filter-beds. Hence the extreme care taken to fill the filter-beds from below, so as to prevent the zooglœa masses being broken by the pressure of air, and to control the rate of filtration and limit the pressure of water on the surface. The degree of fineness and uniformity of the sand grains are also of importance in securing a good filtrate. By using fine sand the current of water which passes through a bed is rendered slow and uniform, and the walls of the lacunar spaces are approximated, permitting molecular action to take place and giving greater firmness to the gelatinous layer. Hence the work of a filter-bed is partly mechanical and partly vital.

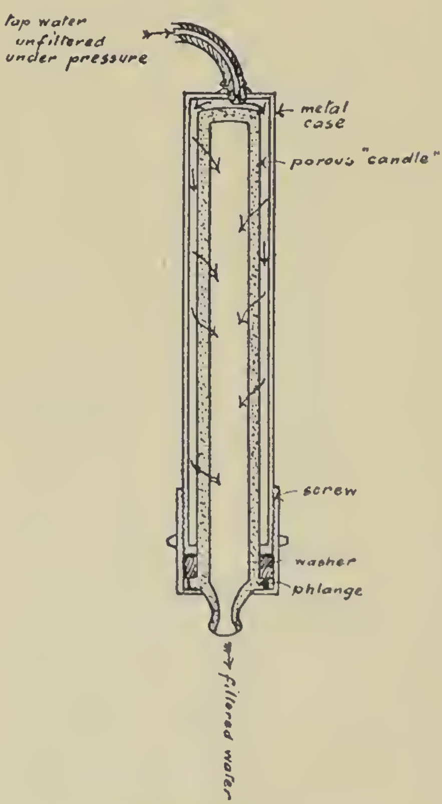
Owing to their relatively slow rate of filtration, and the expense, care, and time needed for their cleansing and resting, the gravity sand and gravel filter-beds have been subjected to some criticism. As an outcome of this criticism, what are known as "mechanical filters" have been devised The essential idea in these installations is to dose or prepare the water with from $\frac{1}{10}$ to 1 grain of sulphate of alumina per gallon, which instantly produces a gelatinous, sticky coating of insoluble hydrate of alumina on the sand bed; this serves as an adjuvant to the filter for the holding back and arrest of fine suspended matter and micro-organisms

in the water passing through. Filters of this kind have been in use in America for some years, and an efficient representative of the type in this country is the Bell patent filter. The chief advantages of this type of filter are ease and simplicity of manipulation, small space occupied, rapidity of flow, and general independence of gradients. For removing lead and iron from water these filters are well spoken of. Another kind of filter for public supplies is that known as the Candy filter. In this system the water is first saturated with air, forced into it under pressure, and then strained by passing it through a specially prepared patent filtering medium contained in cylindrical chambers or drums. A successful installation of this kind is in use at Longmoor, near Bordon, where the excessive presence of iron in the water necessitates special treatment.

The foregoing methods are all designed for dealing with water in considerable quantities. Although it is customary for water supplied by public companies to be sufficiently purified before distribution, so as not to require filtration, yet circumstances exist, notably in the Army, in which filtration by the individual is often a necessity. Filtration on a small scale is a somewhat elastic term, and may range from simple clarification, or the removal of mud and grosser impurities, to true filtration, or the removal of bacteria and other minute forms of suspended matter. Clarification, or coarse straining of water, can be carried out by a variety of means, such as passing muddy water through canvas, blankets, and other fabrics; the procedure can often be improved by dusting the strainer with wood ashes or sand, or even alum. For domestic filtration, from time

to time, a variety of materials have been suggested and used, more particularly charcoal and spongy iron. These are quite unreliable, especially the silicated carbon blocks, still frequently seen. All recent work goes to show that the only media which can be regarded as satisfactory for water filtration in relatively small quantities are certain clays, porcelain, or patent combinations of sand with clay. Pure porcelain, owing to the closeness of its texture, is not of all-round utility, delivering water but slowly; on the other hand, some of the infusorial earths are satisfactory in respect of the rapidity of flow through them, but not free from risk, owing to their softness and fragility. In our experience some of the best domestic filters are those made of judicious mixtures of sand with selected clays; these are moulded into cylinders or bougies, enclosed in metal jackets, and the water forced through them under pressure varying from 20 to 40 lb. on the square inch. The usual type of these filters is shown in Fig. 14, where the filtering candle is attached to

Fig. 14.



Tube filter fitted to tap.

an ordinary tap and the water forced through the medium by the pressure of the water in the main. In the portable or detachable types the water is placed under pressure by means of an attached pump, and so forced through the filter. The action of these filters is merely to hold back the suspended matter, including micro-organisms in the water, these being collected on the surface of the filter. This fact leads to gradual clogging of the pores and a lessened flow of water through the filter. When the output becomes diminished the candle needs cleaning by rubbing and br shing the surface under water. This process in course of time weakens the filter by removing some of its substance, but with care the life of an individual bougie or cylinder can be made to extend over a couple of years. A more serious risk attaching to the routine and unintelligent use of filters of this kind lies in the fact that in the course of time pathogenic bacteria, if present in the water under filtration, are capable of working their way into the pores of the medium, and even through its mass, so as to appear in the filtered water. In this passage through the actual filter they are helped by the pressure under which the water is forced through. The result of this is that one of these filters, if used for the filtration of dirty water, frequently becomes a seriously infected mass, and a possible means of polluting an uninfected water passing through it. As the coarser media constitute the material of which the greater number of these filters are made, we must for safety's sake sterilise these candles or cylinders every fourth day by boiling them in water. This is the regular practice in the

Army, where large numbers of these filters are in general use.

The use of filters of this kind, more or less adapted for field conditions, has been practised in our army for some years. The earlier types took the form of semi-rotatory pumps mounted on a tripod, which forced water through one or more clay filter tubes. Experience in the field indicated these to present many defects, so much so that we regard them as quite obsolete. The modern filter in our service is constructed on the principle that, while dependence must be made on a hard clay tube to actually remove bacteria, a preliminary clarification of water is essential to save the work thrown on the sterilising filter itself. The best clarifying material for this purpose we find to be a mass of coarse sponges closely packed under pressure in a chamber, while the filter itself is a tube of specially prepared hard clay having a central core of perforated aluminium. Designed on this principle, there are three kinds of field filter, namely, (*a*) filter water-tanks, (*b*) mule filters, and (*c*) coolie filters. Each of these is intended for work under certain conditions

The filter water-tank is shown in Fig. 15. It consists of an ordinary water-tank on wheels, to which are fitted two semi-rotatory pumps, two sets of sponge clarifying chambers, and two batteries of filter tubes; each battery contains four tubes, 19 ins. long and 2 ins. in diameter. In addition there are two hoses for connecting the pumps with the source of supply, a special metal vessel in which the tubes and sponges can be sterilised by boiling over a camp fire, and a box containing spare filters, washers, screws, nuts, and other

essentials. The arrangement of the parts is such that the pump, sponge chamber, and filter battery of one

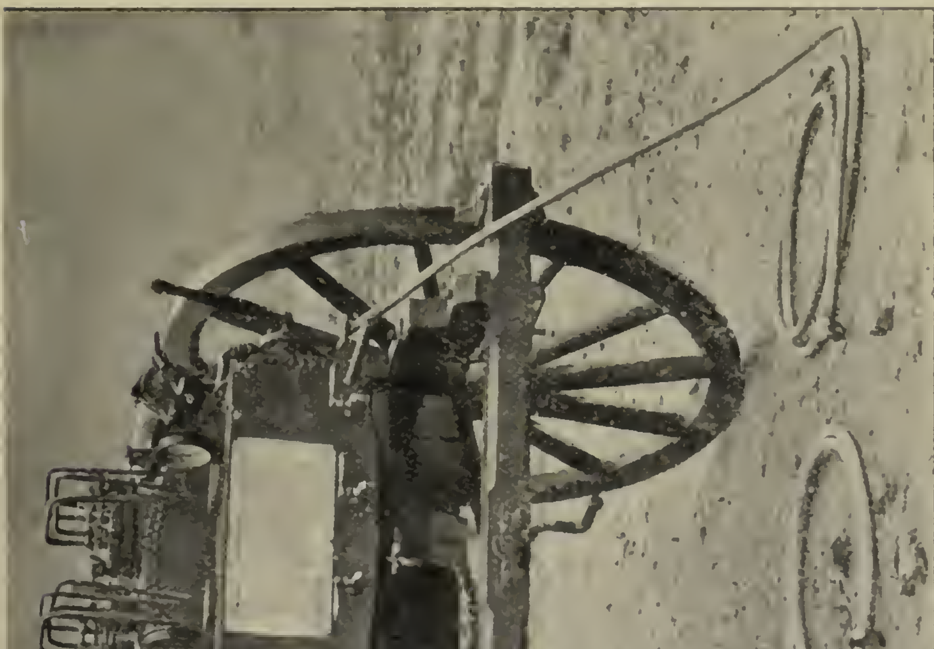


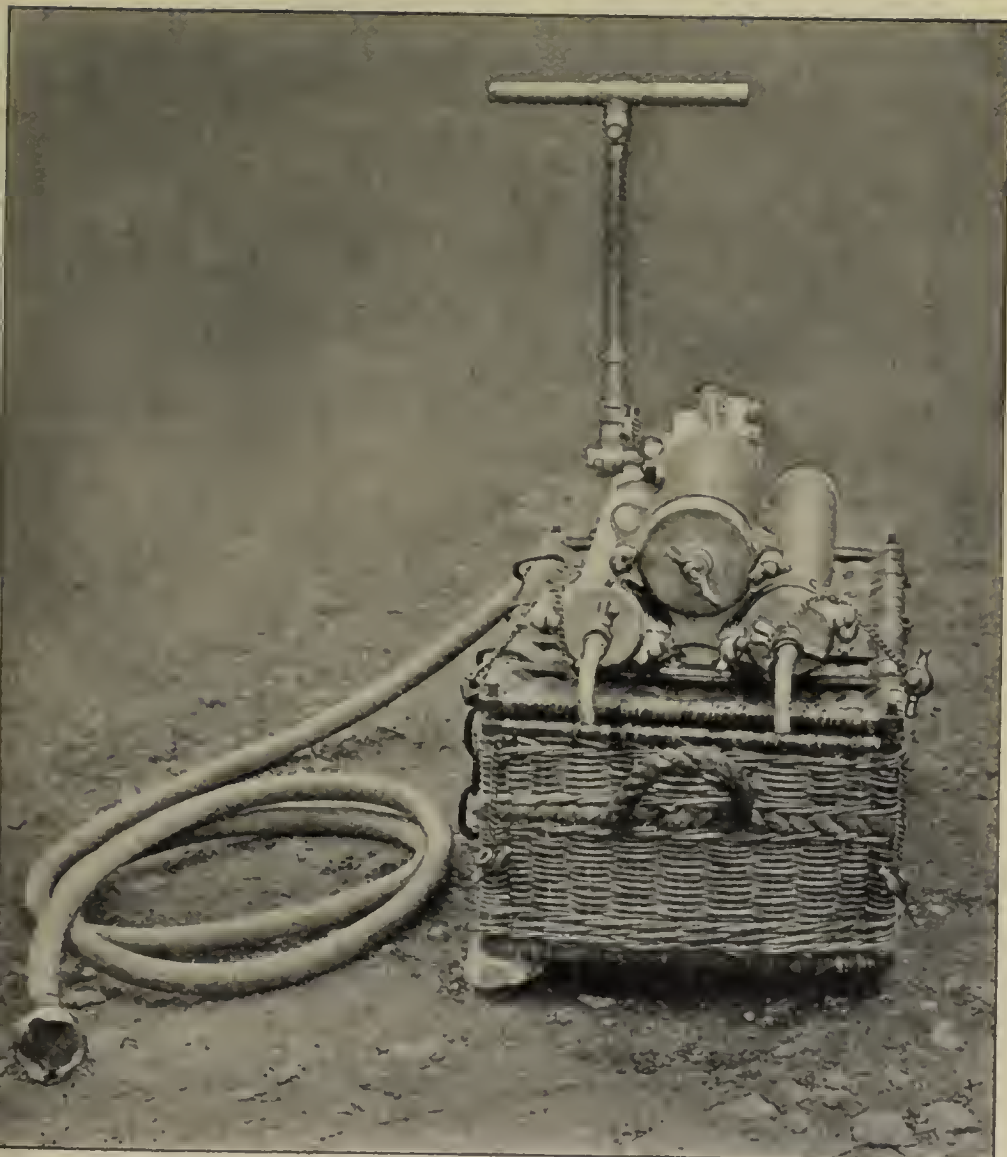
FIG. 15.—Water Tank fitted with Filter.

side are independent of the corresponding fittings on the other; and, although both series can be worked synchronously, should anything go wrong with one

set the other can continue to work. The tank holds 110 gallons of water, and provided the supply be not excessively muddy the cart can be filled, working both pumps, in half an hour. The water, as it flows into the tank, is merely pumped through the sponge chambers, so that the tank is filled, not with filtered, but with merely clarified water. By changing the setting of the cocks the same pumps pass the contents from the tank once more through the sponges, then through the filter batteries, enabling it to issue from the swan-neck outlets into the distributing tank as sterile water. The cocks can be so adjusted that, in case of need, the water can be filtered and delivered direct from the source of supply without going into the tank at all, or one pump can be worked in that manner and the other be used for filling the tank. Once filled, the tank can be emptied in half an hour, using both pumps. Our experience with this filter water-tank has been very satisfactory; it is simple to work, efficient, and the tubes or candles are not found to suffer damage. The sponges need washing and cleaning once a week, the filter tubes must be sterilised by boiling every four days, while the tank itself must be flushed out fortnightly or as circumstances demand. Two trained men are needed to look after and work one of these carts. These men are specially instructed and drawn from the Royal Army Medical Corps. One cart is needed for each five hundred men, or two to an ordinary infantry battalion.

The so-called mule filter is intended for carriage on a pack-saddle, two of these travelling readily on either a mule or pony. In places where wheel transport is

Fig. 16.



Field Service Filter, for Carriage on Pack-saddle.

impracticable their value will be great. One of these filters, ready for use, is shown in Fig. 16. It consists of the usual semi-rotatory pump, with 15 ft. of hosing,

connected with a central clarifying chamber full of sponges, from which the water passes into two laterally placed filter cylinders. This apparatus delivers a gallon a minute readily when the water is reasonably clear, but even when filtering very muddy water the delivery does not fall below 54 gallons an hour. The filter is fixed on a wickerwork platform or base, which, on being turned upside down, makes the lid or top of a basket case into which the whole fits; the detachable lid is fastened to the main basket by means of screw nuts. In the basket cover are carried two spare filter tubes and the hosing. The weight of the whole installation when dry is 68 lb.; wet, it weighs 71 lb. To secure lightness aluminium is freely used, while the wickerwork is strengthened by bicycle tubing. All detachable parts are fixed by small chains, so that nothing can be lost. The filter tubes are identical and interchangeable with those fitted in the batteries of the filter water-tank. We regard this pack-saddle filter as an enormous advance on any previous types; it is more portable, gives a greater delivery of water, and is less trouble to work than any we have ever tried. Four filters on two pack-animals will suffice for an infantry battalion, while two on one animal will be enough for a cavalry regiment.

The coolie filter is on similar lines to the foregoing, only weighing 40 lb. and presenting but a single filter tube of standard size. The clarifying sponges are located in the axis of the filter, and not in a laterally placed chamber. For mountain warfare, where even pack-animals cannot go, these forms of filter should meet a great want. A man can carry one of these

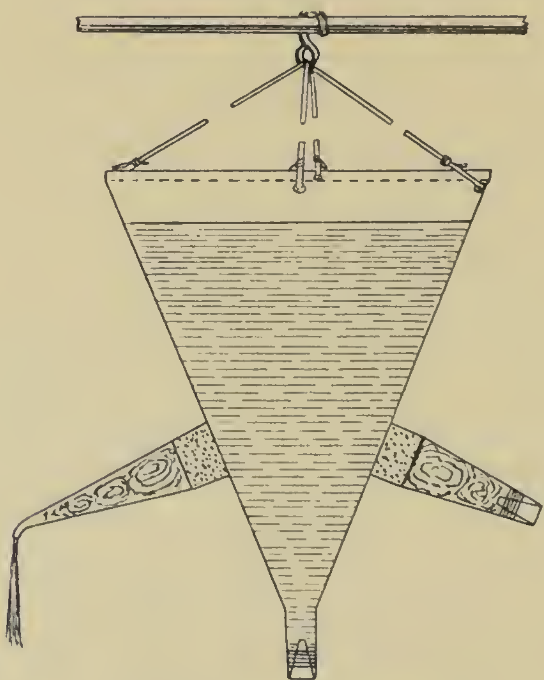
filters easily strapped on the back. The delivery from one of them averages 20 gallons an hour.

However excellent may be the foregoing apparatus, it must be borne in mind that they will not filter very muddy water, and must not be expected to. Further, circumstances may arise when they are not forthcoming; for this reason the soldier must be prepared to improvise filters or some form of apparatus which will at least serve to clarify muddy water, even if it does not remove micro-organisms. If after clarification the water be still open to suspicion, it can be sterilised by some other means—that is, by boiling, or by passage through an ordinary filter, if available.

The simplest way of accomplishing hasty clarification is to pass the water through blanket or coarse sacking stretched on an improvised wooden frame, dusting over the fabric ordinary wood ashes from a camp fire. An alternative method may well take the form of some adaptation of the Ishiji filter (Fig. 17), as used by the Japanese in their Manchurian campaign. This consists of a canvas cone attached to a collapsible metal ring, having cords by which it could be hung from a tree branch. From the cone projected canvas arms or funnels, which were plugged with a piece of sponge and a block of granulated charcoal in a perforated zinc cylinder. To facilitate clarification and precipitation of mud from the water, the Japanese added two powders, one being a mixture of potassium permanganate with alum and china clay, the other a mixture of china clay with chloride of ammonium, a little charcoal, and some vegetable extract of unknown nature. In place of these particular powders use could

be made of wood ashes, alum, with or without a little lime or bicarbonate of soda. Such an improvised filter will not remove all germs, but is capable of rendering an otherwise undrinkable water reasonably safe. Many occasions on field service afford opportunities for the

FIG. 17.



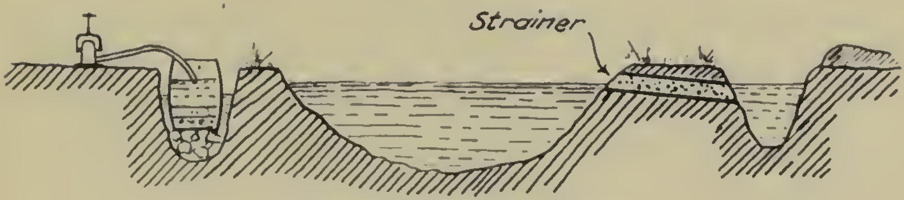
"Ishiji" Camp Water-filter.

exercise of initiative on these lines, which can and should be turned to good account by the soldier.

Another simple way of securing quick clarification, especially of river-water, consists of digging a pit near the proposed source of supply, so that the water may percolate through the soil before being used. A more satisfactory method is to sink a barrel or box in such a pit, and allow water to pass through a wooden trough

packed with clean sand or gravel (Fig. 18). If two boxes or barrels of unequal size be available, one may be placed inside the other and the interspace filled with clean sand or wood ashes. The outer barrel is pierced

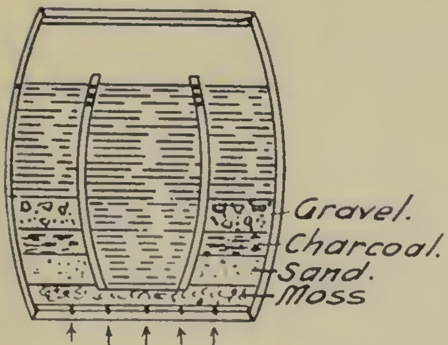
FIG. 18.



Types of Improvised Filter.

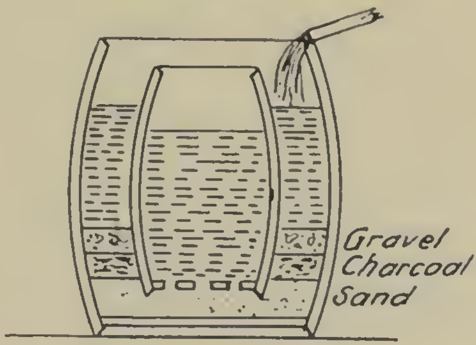
by small holes near the bottom and the inner barrel near the top, the whole being partially submerged in the water to be cleared or filtered (Fig. 19). Where the water supply is smaller this method may be reversed,

FIG. 19.



Improvised Filter.

FIG. 20.

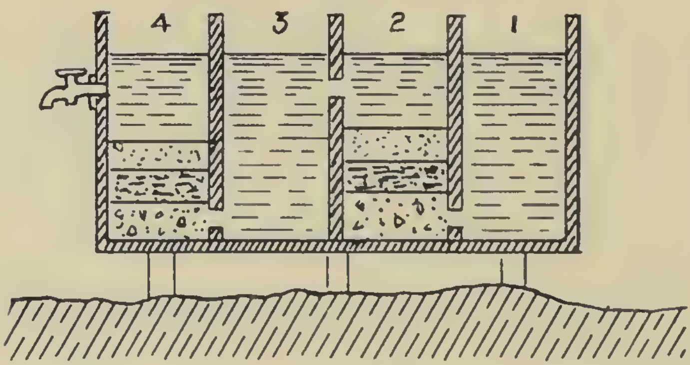


Improvised Filter.

the space between the barrels being filled partially with filtering material and the bottom of the inner barrel being removed, or, better still, perforated. Water is then poured in above the filtering material, whence it percolates downwards, and rises to its proper level in the inner barrel (Fig. 20).

An effective filtering arrangement may be improvised by boring a small hole near the bottom of a suitable receptacle, and partially filling the latter with layers of gravel, sand, and wood ashes from below upwards. The water to be clarified is poured in at the top, passes through these layers, and is collected as it emerges from the apertures below. The depth of the filtering media will vary according to the size of the receptacle, but an average may be taken as three inches of gravel, twelve

FIG. 21.



Improvised Filter.

inches of sand, and three of ashes. Periodically the material will need cleansing and changing. The working head of water will be about six inches. Should a large box be at hand, it may be made to serve both for the filtration and storage of water by dividing it into four compartments by suitably pierced partitions. Two of these spaces may be partially filled with sand, gravel, and small pebbles from below upwards, the muddy water being poured into a chamber at one extremity, and, after being twice filtered, removed by a spigot at the other end. This is a very successful form of improvised filter, but is open to the objection that it is difficult to

make the partitions sufficiently tight to prevent leakage of unfiltered water from one compartment into another (Fig. 21).

In improvising filters of the above characters care must be taken to get real sand, and not use sandy marl in which there is much clay. This latter, when wetted, binds and forms so dense a mass that percolation of water is slow and often absent. It must, further, be remembered that all improvisations of this kind are mere makeshifts and, unless the material be periodically renewed and the water not allowed to rush through too quickly, may be a source of danger. The addition of a small amount of alum, say a tablespoonful to each ten gallons or every four bucketfuls, is an advantage, since it produces a jelly-like precipitate which materially helps in arresting and entangling the more minute particles held in suspension.

Purification by Heat.—There are three main ways in which heat can be applied for the purification of water. These are distillation, boiling, and the employment of special apparatus on the heat-exchange principle.

Distillation is employed rarely on land; its applicability is limited practically to shipboard and to a few places abroad dependent upon sources of supply which are not only organically impure, but also brackish. If efficiently carried out, distillation yields a pure and safe water, though the final product is often flat and dull, owing to loss of dissolved gases. One of the greatest objections to distilled water is its indifferent storage qualities, particularly in hot countries.

Boiling is limited to the purification of water in small

quantities, and, though ensuring the destruction of micro-organisms, presents the objections of being extravagant in fuel, makes the water flat and insipid, and leaves the finished article too hot for immediate use, except as tea, coffee, or cocoa. Canney has designed a boiling vessel which will give 36 gallons of safe water per hour with an expenditure of 2 pints of kerosene oil; but as it is estimated that the issue of these apparatus for 10,000 men would entail at least 140 mules for their transport and of the necessary fuel to last fourteen days,* we are forced to consider the scheme unworkable, and to attempt to reach the same end by alternative means, such as by using the ordinary camp kettles. Possibly, in the near future the soldier will receive a metal water-bottle so constructed that he can boil its contents himself over any camp fire, but until he can boil water for himself in small quantities it must be done for him in bulk. How to do this economically and rapidly constitutes a difficult problem. The Japanese attempted to do so by the use of water-boilers fixed on the frame of an ordinary cart. The general principle of construction appears to have been that of an inner jacket, shaped like an inverted cauldron, with a circular hole for the chimney and another for the stoke-hole, riveted on to an outer cylindrical jacket, so as to form a reservoir for the water between the two jackets and leave a large central space for the fire. Ordinary wood was burnt, and as the capacity of the tank was 15 gallons it took three-quarters of an hour to boil the first filling; subsequent fillings took from twenty minutes to half an hour. We ourselves

* McGill, *Journal of the Royal Army Medical Corps*, iii. 516.

have been experimenting with portable heaters on this line, but with indifferent success. For fixed camps and posts of position a simple and convenient apparatus is the Holdaway boiler. We have had some experience of it, and found it to work well, 200 gallons of water being boiled in an hour. It burns wood, but being somewhat heavy is unsuited for moving columns.

If water is to be sterilised by heat in any quantity for the soldier it will be most economically done by means of some form of apparatus designed on the heat-exchange principle. This, as applied to the purification of water, depends on the fact that with a sufficient area of metallic surface of good conducting capacity, and sufficient time, a given quantity of liquid will yield nearly all its heat to an equal volume of the same liquid. In applying this principle to any practical apparatus the incoming cold water is made to receive heat from the outgoing hot water, and in this way the double advantage gained that the amount of fuel required to raise the water to the required temperature is much lessened, and the water issuing from the apparatus is almost as cold as that originally supplied.

There is a variety of these water-sterilisers on the market, the better known being that of Vaillard and Desmaroux, that of Hartmann, the Lawrence, the Forbes, and the Griffith. The two first named are respectively of French and German make. They both sterilise water, delivering it only some 5° C. hotter than when it entered the apparatus. The great defect of both these types is that they are heavy and cumbersome; in fact, a machine capable of delivering 110 gallons of water an hour weighs over a ton. The smaller

types are equally heavy in proportion to the amount of water they sterilise; moreover, they are distinctly complicated in design. We have given these apparatus a considerable amount of personal attention, and are convinced that for general military needs, certainly in our own army, these Continental machines are of little value. It is only fair to say, however, that both the French and German military authorities speak well of their respective types. The Forbes machine is of American make. When first brought out and used both by the Americans in their Philippine campaign and by ourselves in South Africa and Somaliland this apparatus was small and capable of yielding but 25 gallons an hour. This type is now regarded as obsolete, and has been replaced by the "army water-waggon," which is a complete plant containing boiler, pumps, strainers, steriliser, storage tank, &c., mounted on four wheels, and capable of being drawn by two horses. We have not had an opportunity of trying this machine, but reports indicate that it delivers 300 gallons of sterile water in the hour, and has storage capacity for 150 gallons.

The Lawrence and the Griffith are both of British make and design. The former is packed in a steel tank or case measuring 3 ft. 7 ins. by 2 ft. by 1 ft. 3 ins., and weighs 196 lb. It yields 45 gallons of water an hour, which leaves the apparatus at a temperature of 15° F. above that of crude water. In this machine, as in the Forbes, the heat is obtained from a lamp burning mineral oil under pressure; the consumption averages $1\frac{1}{2}$ pints an hour. We have given this steriliser an extended trial, and found it to work

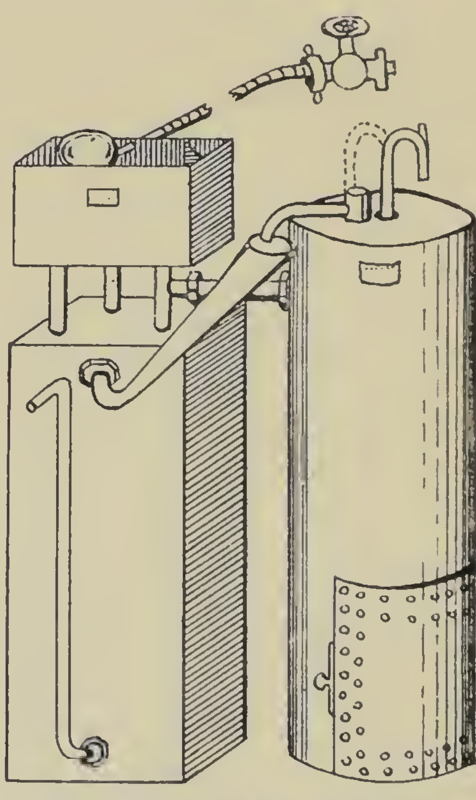
rapidly and well. Its chief defect is that it is heavy and awkward to handle. For fixed camps we regard this machine as a distinct advance, and capable of useful work.

In all the foregoing sterilisers the water is brought to an actual temperature of 212° F. or upwards; that is, it is boiled, and the natural expansion of water when in a state of ebullition utilised as the motive force to secure an adequate circulation of water through the apparatus. In the Griffith steriliser the essential feature is the recognition of the fact that an exposure of 15 seconds to a temperature of 180° F. is sufficient to destroy all disease-producing micro-organisms that are conveyed by water.* When first designed the Griffith steriliser was a comparatively small apparatus. Its general appearance when fitted up is shown in Fig. 22, from which it will be seen to consist of two main parts, namely, a heater, on the right, coupled to a recuperator or cooler constructed on the heat-exchange principle, placed to the left. Above the cooler is a small supply reservoir, to which the water can be conveyed by hand, or from a suitable tank or water-cart by means of the hosing, the flow of water through this duct being controlled by a screw tap and a ball valve. The heat is obtained from an oil lamp working on the pressure principle, placed beneath the heater within the door shown in the diagram. The two main parts are detachable, so that the whole apparatus packs into two boxes, each measuring 4 ft. by 1 ft. by 1 ft. One box with contents weighs 80 lb., and the other 84 lb. This small

* Griffith, "Heat as a Means of Purifying Water," *Journal of the Royal Army Medical Corps*, vii. 226.

steriliser will yield 60 gallons of water in an hour, the temperature of the outgoing water being 12° F. hotter than that going in. The expenditure of oil averages $1\frac{1}{2}$ pints per hour, or, roughly, half an ounce for each gallon of water sterilised. The vital part of the Griffith

FIG. 22.



The "Griffith" Water-steriliser.

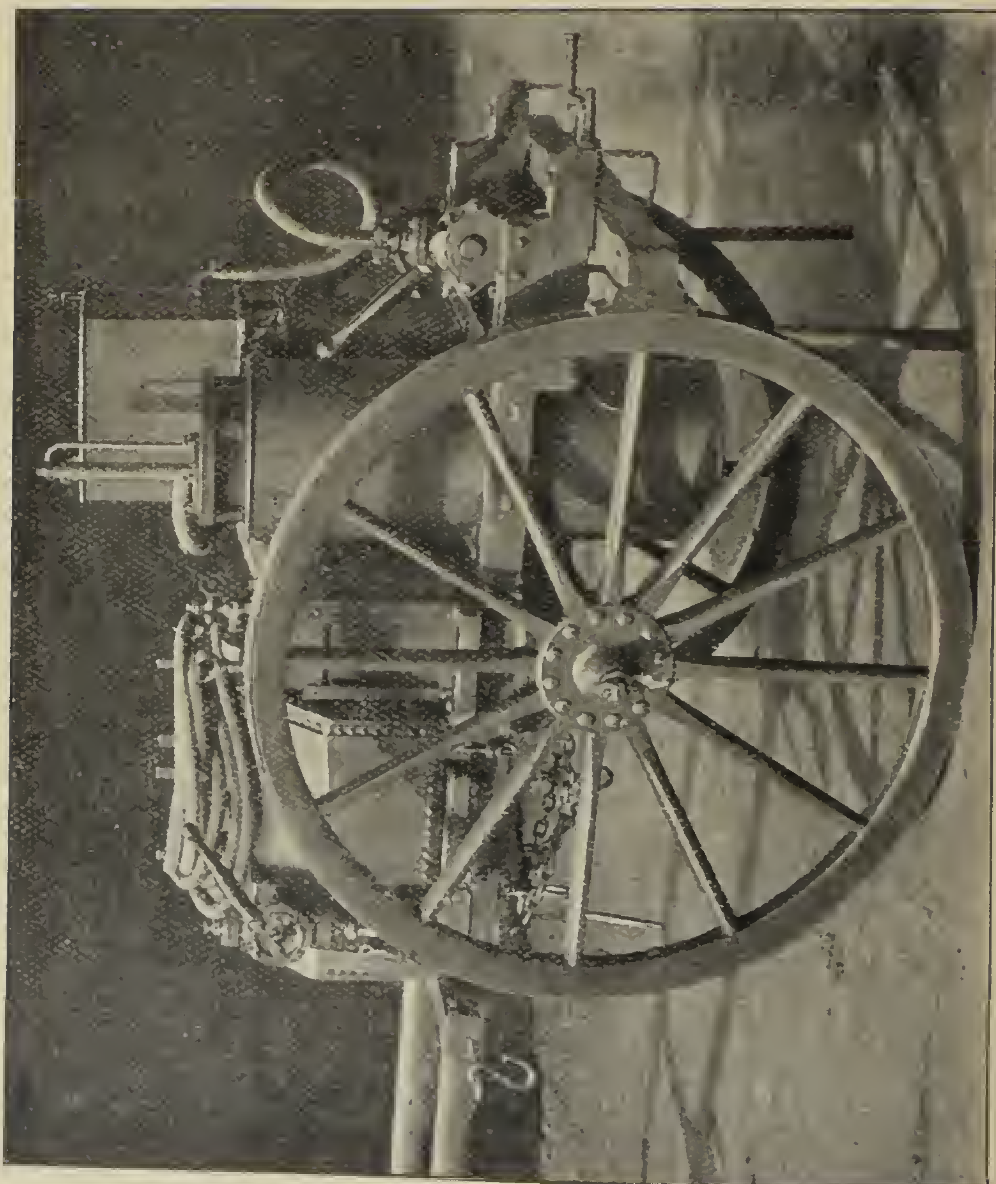
apparatus is the valve, which controls the passage of the water from the heater to the cooler, and which cannot be seen in the figure, as it lies concealed within the heater. This valve is so made that it expands or opens only when the water attains a temperature of 180° F., closing automatically when this temperature is not maintained. We have had considerable personal ex-

perience of this steriliser, and find it reliable, easy to work, and yielding a sterile water. It is far from perfect and is capable of further development, but, taking into consideration its size, weight, portability, facility and rapidity of working, its water delivery and consumption of fuel, we consider this to be probably the best form of apparatus of the kind suitable for military needs.* A later type of this machine, much larger, and mounted on wheels, in connection with a water storage tank gives 350 gallons of sterile water in the hour. Being larger, this steriliser is much more economical of fuel than its smaller prototype, the consumption of oil working out over a long series of trials with troops in the field at 1 gallon of oil for the sterilisation of 480 gallons of water. This apparatus, while not free from faults, is handy, easily worked, and capable of delivering safe water within twenty minutes of filling. A general idea of this steriliser is shown in Fig. 23. An alternative type, somewhat on the lines of the first or small machine, but much larger, has recently been introduced into the service, capable of turning out a couple of hundred gallons of water in the hour, and transportable as a single package, or probably two packages. This improved form will be of great practical value in the purification of water in fixed camps or posts on lines of communication. Unless mounted on wheels, none of these heat sterilisers are of utility with moving columns.

It is difficult to say what part these heat sterilisers will play in the future as means of purifying water for

* Firth. "The Griffith Water-Steriliser." *Journal of the Royal Army Medical Corps*, vii. 218.

soldiers. In the form in which they are available at present we think their utility will be greatest in camps



where their steady supply with water can be secured. A practical difficulty with all apparatus of this kind is

their unsuitability for dealing with very muddy waters; where such is the only source of supply some preliminary clarification is desirable, otherwise the sterilisers will silt up. This contingency complicates matters and militates against their general use with mobile columns, but in camps or fixed posts facilities can be readily found for rough clarification of the water before passing it into the tanks supplying the heat sterilisers. In the new type this difficulty is overcome. The Army at large at present fails to appreciate the practicability of these apparatus. Speaking from intimate personal experience of their use with troops, we are convinced that they afford the only true solution of the question of how to supply troops with a safe drinking water. The large Griffith machine on wheels was tried with both the First and Second Divisions at Aldershot in 1907, during divisional training. On the first occasion it was able to supply and fill the ordinary water-carts of one and a half brigades or six infantry battalions. This meant the filling of twelve water-carts twice a day, or, roughly, 2400 gallons of water. Located on the banks of a brook in the charge of a detachment or water squad of a sergeant and five men of the Medical Corps, this steriliser served as a water dépôt from which the various regimental water-carts were filled, these latter being in sole charge of the driver of the horses, who had merely to bring his cart in suitable proximity to the steriliser for filling. On the second occasion the same satisfactory results were obtained. In this case it was the purifier of water for two brigades of field artillery and two squadrons of cavalry. If utilised as a brigade unit, sterilisers of this or similar type might be made to con-

stitute the base on which the whole water service of the brigade could rest. Such an arrangement would permit of the withdrawal of special water-squad men with individual water-carts, as they would have no technical apparatus attached to them, but involve merely one water squad of trained men with the steriliser itself. This squad would for efficiency be one N.C.O. and five men. As a unit with brigade headquarters its daily location at any convenient source of water-supply would be essentially a question for the brigadier, as the disposition of his command might demand. Its location, marked by the usual watering-place flag, would be the rendezvous for all regimental water-carts requiring to be filled. At present any organisation for a pure water service in the field on these lines has not received official favour, mainly owing to the fact that it involves the addition of at least two wheels and two horses to the transport of a brigade. The fuel question is not a serious matter. We are disposed to think that as the capabilities of these sterilisers are more widely understood their gradual use with moving columns is bound to come. For the time being official policy is to confine the use of agency of this nature for water purification to fixed camps and posts on lines of communication.

Purification by Chemicals.—This is a subject as to which much ignorance and prejudice exist, particularly in the service. In spite of the natural objections to the "doctoring" of water, the possibilities of chemical processes for the purification of water are well worth the notice and serious attention of soldiers. Many of the procedures suggested act by producing a

precipitate which carries down suspended matter and micro-organisms. *Alum* has been used to purify water from suspended matters. It does this very effectually if there be calcium carbonate in the water; calcium sulphate is formed, and this and a bulky aluminium hydrate entangle the floating particles and sink to the bottom. For waters deficient in lime the addition of sodium bicarbonate is advisable to neutralise the alum. The quantity of crystallised alum to be used should be about 6 grains per gallon. On similar lines *potassium permanganate* is added to water for purification purposes, with the idea of suspended matters being carried down by the formation of a precipitate of manganic oxide. We have had considerable experience of this method, and find the formation of this precipitate to be very uncertain. The addition of a little sulphate of iron, however, materially increases the precipitating action. The treatment has its value, acting mainly as an oxidising agent and germicide. It has been carried out for many years in India, where the water in wells and tanks has been regularly rendered rose-pink in colour by means of this reagent in times of cholera. No precise quantity of the salt has been used, the rule being simply to add enough to make the water pink for half an hour or so. The results have been most satisfactory, cholera-tainted sources of water-supply being made relatively safe. The treatment gives no unpleasant taste to the water; the main objection is the colour, which is apt to offend the fastidious, prejudiced, and ignorant.

The chemical treatment of water in bulk has not received much attention in this country. The most

recent, and probably the most extensive, trial of purification by simple chemicals was the treatment of the Lincoln water-supply in 1905 by sodium hypochlorite, containing 12 per cent. of free or available chlorine. This was added to the water in the reservoirs in the proportion of 1 part of the salt to 100,000 parts of the water, or 7 grains to each 10 gallons. As judged by the lessened number and improved quality of the bacteria in the water, this was the smallest quantity giving satisfactory results. By giving a sufficiently small dose and a prolonged contact, dechlorination of the water seems to have been unnecessary, though the treated water is said to have had a mawkish or so-called "spent" taste. Lincoln at this time was afflicted with a serious outbreak of enteric fever, undoubtedly water-borne, but the result of this treatment of its water seems to have been distinctly successful.

Copper as a means of purifying drinking water in bulk has been brought forward very prominently in America, especially in regard to the removal of algæ and confervoid growths in reservoirs, where their presence produces a bad odour and taste. The same problem has occurred in this country. Practical trial indicates that the sulphate of copper must be added in not less proportion than 16 grains for each 100 gallons of water in a reservoir. In this dilution it will not hurtfully affect the consumer. The simplest way to secure free diffusion is to tie the sulphate up in linen bags, attach these to punts or boats, and tow them about the water to be treated. As a germicidal agent copper needs to be added in considerable quantities, and the period of contact to be at least twenty-four hours. In clear water

1 grain per gallon is fairly efficient in removing sewage organisms, in turbid waters the amount must be trebled, and in very foul waters quite 7 grains to the gallon must be used. For routine consumption these amounts of copper in a water are open to grave objection. The effect of standing water in clean copper vessels has no destructive effect on the contained micro-organisms.

Chlorine, derived from the electrolysis of saline solutions, presents some promise as a means of purifying water in bulk, but, as in the case of using *ozone* for a similar purpose, the procedure has not reached a practical form.

Looking at the subject of water purification by chemicals purely from the military point of view, we find that a considerable number of reagents have been advocated for use on field service. Some are reliable sterilising agents, others are not, while many present the further disadvantage of adding taste and colour to the water. In Austria the use of hypochlorite of calcium in the strength of 0·02 gramme to the litre of water has been advocated, but as any excess over this amount renders the water unpalatable and there are practical difficulties in the way of making it up in tablet form of definite dosage, the objections to its systematic use with troops in the field are consequently great.

Bergé * advocated peroxide of chlorine, generated by the action of sulphuric acid on chlorate of potash. Whatever may be the merits of this method as a steriliser of water, it is evident that it must be carried out with care,

* Bergé, "Proceedings of the International Congress of Hygiene and Demography," Paris, 1900.

and the issue of such a reagent as sulphuric acid to soldiers in the field is obviously impossible. Equally fantastical is Nesfield's proposal* to purify water in bulk for soldiers by means of chlorine liquefied under pressure and stored in lead-lined iron cylinders. He advocates 7·5 c.c. of liquefied chlorine, representing 10 grammes, to be slowly discharged into 18 gallons of water, and subsequently dechlorinated by sodium sulphite. We have tried this process practically; it takes quite half an hour to discharge the chlorine if its maximum effect is to be secured, and even then sterilisation is not absolutely certain. Apart from these facts, practical difficulties exist as to the supply of cylinders of compressed chlorine with an army in the field. Nesfield's other suggestion, to sterilise small quantities of water by means of tablets containing a mixture of bleaching powder and sodium bicarbonate, is also unreliable; in our experiments, using 1½ grains of bleaching powder to a pint of water, sterilisation was not secured after an hour's contact.

Schumberg proposed the addition of 0·06 gramme of bromine, enclosed in a glass capsule to a litre of water, securing sterilisation in five minutes, and then debrominising by adding small tablets of sodium sulphite. This is undoubtedly an efficacious procedure, and was practically tested in the Sudan expedition of 1898. The results were, however, not satisfactory, as the difficulties in the way of carrying large quantities of the reagents were considerable; we are of opinion, however, that had the organisation been more thorough

* Nesfield, "A Chemical Method of Sterilising Water," *Public Health*, 1903, xv. 601.

and the trial of this reagent been less hurriedly made the results would have been considerably better. Our own experiences with these bromine globules and debrominising tablets suggest that the process is effective and practicable; we think it has been insufficiently tried.

In 1901 Rideal and Parkes * suggested the use of sodium bisulphate as an effective means of destroying pathogenic bacteria in water. They advocated the addition of 15 grains of this reagent to a pint of water. A somewhat acid taste is imparted to the water by this salt, but such germs as the cholera vibrio, the enteric and dysentery bacilli are certainly killed by half an hour's contact, though absolute sterilisation is not secured. Tablets of bisulphate of sodium were issued and tried with our troops during the later stages of the South African War, but the experiment was too hastily planned and too irregularly carried out to warrant any precise decision as to the merits or demerits of the proposal. We have recently tried this method on a large scale with troops, using tabloids each containing 30 grains of the bisulphate, sweetened, and flavoured with oil of lemon. One of these tabloids suffices for 1¾ pints of water, or the contents of a soldier's water-bottle. The water is sterile in twenty minutes, and tastes not unlike lemonade. Having explained their use to the men, no difficulty has been experienced in getting them to use them. The degree of acidity imparted to the water is quite insufficient to render it unpalatable or dietetically hurtful. From the simplicity

* Rideal and Parkes, "The Chemical Purification of Water," *Trans. Epidem. Soc. London*, 1900–1, N.S., xx. 62.

of the technique involved, we are very sanguine that practical results may be obtained by a further and extended trial of this reagent by soldiers in the field. For mounted troops, for whom it is difficult to organise a system of filtration or sterilisation of water by heat apparatus, the use of tabloids of this nature seems to offer a reasonable solution of a difficult problem.

Another method which we have investigated and tried depends upon the liberation of iodine by a weak acid from a mixture of iodide and iodate, provided in tablet form. The practical value of this reaction for sterilising waters was first pointed out by Vaillard,* who employed the reagents in three differently coloured tablets. If the first and second tablets be crushed and dissolved in a little water a brown fluid containing 0·06 gramme of iodine results; this is sufficient, if added to a litre of water to destroy its contained micro-organisms in ten minutes. The subsequent solution of the third tablet deiodises the water and renders it fit to drink. The residual chemicals in the water after sterilisation are harmless. This is undoubtedly a very elegant process, and we have satisfied ourselves of its efficiency to sterilise heavily fouled water. Excellent as it is, there are grave difficulties in the way of employing it for use by soldiers, and we are obliged reluctantly to regard it as impracticable for general service requirements. For the officer it affords an excellent means of sterilisation of his water-bottle contents. Recognising the merits of this iodine process, we have endeavoured to apply it to the sterilisation of

* Vaillard, *Archives de Médecine et de Pharmacie militaires*, No. 7, 1902.

water in bulk, such as 100 gallons when contained in water-carts. The results have been unsatisfactory, mainly from the fact that there are technical difficulties in the way of making tablets containing a sufficiency of the essential reagent to deiodise so large a quantity of water. If these can be overcome there is every reason to believe that a definite system of purifying water in tanks and carts could be organised, working on these lines and with these reagents.

These, then, are the main facts as to methods of purifying water either actually tried or suggested for trial by troops in camp or the field. For all-round utility we are disposed to give the first place to filtration methods, especially in view of the fact that the newer types of filter are free from the defects of earlier apparatus. If it can only be carried out, sterilisation of water by heat is undoubtedly the safest line of defence; but, as explained, the apparatus available for this purpose are still difficult of practical utilisation by soldiers in time of war. Doubtless in the near future the present disabilities will be remedied, but as matters now stand sterilisation of water by heat is essentially a method for camps and fixed posts, where installations, working on the heat-exchange principle and subjecting water to a temperature of 180° F. for a few seconds, can deal with considerable volumes of water both efficiently and economically. The utilisation of chemicals for purifying water in camps and in the field is very promising theoretically, but its practical application is full of difficulties. We ourselves have devoted much personal effort to a solution of the water question on these lines, and reluctantly admit that the use of

chemical methods by individual troops offers but a slender prospect of being generally applied with success. We do not by this imply that the matter is to be dismissed from further consideration; on the contrary, every endeavour should be made to develop the idea. Even with our present reagents chemical methods may be of great use in sterilising water-bottles, tanks, and carts, also for sterilisation of water by tiding men over short periods, when filters cannot be carried or rendered available, but when each man can carry 50 to 100 sterilising tablets. Probably the bisulphate of soda offers the best prospect of success on these lines.

Whatever method of purification be employed, its successful application depends absolutely on the dissemination of knowledge as to the object in view among the *personnel* of an army and the organisation of a system to put it into practice. Regimental and staff officers, as well as the individual soldier, must be thoroughly imbued with the value and necessity of carrying out every detail necessary, and of preventing the use of any water that is not submitted to the process of purification. But this will not be enough. There must be an organised body of men trained in the use and care of all technical apparatus. It was the absence of this trained *personnel* which paralysed our earlier attempts to deal with this question on field service. Highly technical equipment has been issued and handed over in the past to men uninformed, untrained, and often unsympathetic as to its management. Is it any wonder that the utility of this equipment has been seriously doubted? We, in our own

army, are now endeavouring to remedy these mistakes; not only is the knowledge as to the object and aims of water purification being sedulously imparted to all ranks, but definite numbers of men of the Royal Army Medical Corps are being trained in the use of all methods of water purification, and, as water squads, employed both with units and in camps or at fixed posts in the actual supply of purified water to troops. Later, as knowledge spreads, doubtless much of this water service may be carried out by regimental men; the main objection however, to that proposal is the withdrawal on a fresh plea of more men from the fighting ranks, which are already sufficiently depleted by absentees on various other quasi-departmental duties. The development and inauguration of a policy which places the supply of safe water to troops in the field on a systematic basis can have but the best results, the moment we mobilise and take the field, and we look with confidence to a sensible reduction in the incidence of water-borne disease in our future campaigns.

CHAPTER X

THE FOOD OF THE SOLDIER

UNDER this heading two main principles are involved, quantity and quality. To appreciate the facts as to quantity the reader must have at least an elementary knowledge of the theory of dietaries.

Principles of Diet.—Foods are all substances which, after undergoing preparatory changes in the digestive organs, serve to repair or renew the organs of the body and maintain their functions. Foods have been classified as being either *tissue-producers* or *energy-producers*, the first class renewing the composition of the body, and the second class supplying the combustible material the oxidation of which is the source of energy manifested in the body. The two main manifestations of energy in the body are heat and mechanical motion, which are to a large extent interchangeable. All foods are either tissue-producers or energy-producers; they may be both, and in many cases are so. On the other hand, certain foods may serve neither of these functions, but are merely useful in aiding the assimilation of food; such are water, and the various condiments like salt, mustard, and vinegar.

The various substances which constitute food may be conveniently classified into (1) those which contain

nitrogen, (2) those which contain no nitrogen, (3) salts, (4) water. The nitrogen-containing foods are the flesh of various animals, birds, and fishes, also eggs, cheese, the curd of milk, and a few vegetables like peas, beans, and lentils. These nitrogenous food substances are of the first importance, as they construct and repair the tissues of the body. They are not used solely for this purpose, as a large share of the bodily energy is derived from them. We cannot do without nitrogen-containing foods, and any deficiency of them always leads to ill-health. The various foods which do not contain nitrogen are represented by the various fats, oils, sugars, and starches. The fat obtained from food is not simply stored up as such in the body; it is burnt and used in the body as a source of heat and energy. Fat is formed in the body not only from fatty food, but also from starches, sugars, and even meat and other nitrogen-containing substances. The sugars and starches are inferior to the fats in nutritive power, but, being very digestible and cheap, are in much greater favour. During digestion starch is converted into grape sugar, and starch and sugar as sources of heat and energy are practically equal in nutritive power. We cannot maintain good health without either fats or sugars and starches; the best health follows an admixture of them all, but the total deprivation of fat involves more serious consequences than the total withdrawal of sugar and starch. The various salts, especially common salt, are essential to health. The adult human body contains about seven pounds of mineral matter, of which five-sixths is in the bones. The various body salts, like lime, iron, soda, potash, phosphorus, are all derived

from and contained in the various nitrogenous and non-nitrogenous foods. Water forms an important article of diet, constituting quite 65 per cent. of the whole body. In the body, water serves chiefly for the solution and conveyance of food to various parts of the system, for the excretion of useless products, for the equalisation of heat and the regulation of all the chemical and mechanical functions of the body. Water is not received into the body simply as a liquid; it forms a large proportion of the solid food taken; thus, meat contains 72 per cent., bread 38 per cent., cabbage 92 per cent., and butter 16 per cent.

Since any manifestation of energy by the body must have its source in the material which has been supplied to the body in the form of food, it follows that any expression of the nutritive value of the food-stuffs becomes identical with the expression of their value as force-producers. The simplest measure of the amount of power or energy which can be obtained from a given weight of matter is the heat produced during its combustion. As a standard or measure of heat yielded by the combustion of food-stuffs we have the *Caloric*, which represents the heat required to raise 1 kilogramme (1 litre) of water 1° C., or, in other terms, 1 lb. of water 4° F. The mechanical equivalent of this amount of heat is 3058 lb. raised 1 foot, or 1·3 foot-tons. In the case of the majority of food-stuffs their actual value in respect of capacity for heat production has been determined experimentally and expressed in relation to the performance of work; thus it has been calculated that 1 ounce of the following substances, on complete combustion, yield the

following amounts of energy, expressed as Calories: Arrowroot, 96; fat bacon, 252; lean beef, 29; bread, 85; butter, 249; cheese, 116; macaroni, 99; milk, 20; oatmeal, 124; potatoes, 27; rice, 98; sugar, 115; tapioca, 98; and veal, 25. Figures of this kind are useful in showing what energy can be obtained from our food, but it must not be supposed that the value of food is in exact relation to the possible energy which it can furnish. In order that the energy shall be obtained the food must not only be digested and taken into the body properly prepared, but its energy must be developed at the place and in the manner proper for nutrition. The mere expression of potential energy cannot fix dietetic value, which may be dependent on conditions in the body unknown to us.

With regard to external or useful work and the amount of energy required to be supplied by food to produce that external work, it is estimated that under ordinary circumstances a man transforms one-sixth of the total available energy of his food into work, the rest being lost in the form of heat. This loss is inevitable, but it compares favourably with that experienced in a steam engine, where the work done is about one-eighth of the potential energy of the fuel consumed. As the average external work of an ordinary soldier, employed as a clerk, is calculated to be equivalent to some 410 Calories, the total heat value of his food should not be less than six times this, or say 2500 Calories. For a man doing the usual parades and fatigues 3100 Calories are required, while for a man doing harder work, as on manœuvres or field service, the energy demanded from food is not less than 3500 Calories.

So far we have gained an insight into the nature, uses, and nutritive values of the food-stuffs; their functions are clearly to furnish material for growth and repair of the body tissues, and to provide potential energy for expenditure in the form of heat and work. We have now to ask from what classes and in what proportion must food be supplied daily to carry out these functions efficiently. The answer to the first part of the question is, no single class of food, whether nitrogenous or non-nitrogenous, can support life except for a very short period. Life may be supported upon one nitrogenous and one non-nitrogenous food for a very long time, but for a permanency salts would have to be added. For the best forms of diet both fat and sugars or starches are needed in addition to nitrogenous matter. Then, as to the relative proportions of each, experience and experiment indicate that an average man needs daily, free of water, at least 4 ounces of nitrogen-containing food, 2 ounces of fat, and 18 ounces of sugar and starch. Expressed in terms of everyday articles of food, this is represented by beef, 9 ounces; cheese, 1½ ounce; butter, 1½ ounce; bread, 12 ounces; potatoes, 10 ounces; sugar, 1 ounce; milk, half a pint. Roughly, in such a dietary the nitrogenous foods are to the non-nitrogenous as 1 is to 5, and the fat is to the sugar and starch as 1 is to 10. A critical analysis of individual and class diets shows that the greater numbe conform to these standards.

Various conditions of life influence the amount of food required; the more important of these are work, rest, weight, age, sex, and climate. With an increase of muscular work there must be a corresponding in-

crease in the total amount of food consumed, and as modern research indicates that muscular work makes no special demand on one nutritive constituent more than another, it is logical to assume that all must be increased. In the diet of the restful or passive life the fats and sugars or starches should be relatively more restricted than the nitrogen-containing foods, because during rest the excretion of carbon dioxide is more affected than that of nitrogen. As bearing on the demand for food, the influence of build and age appear to be of more importance than weight and sex. Thus a man whose weight is due mainly to muscle will require relatively more food, especially nitrogenous food, than one who owes his weight to bone or fat. The young, relatively to weight, require more food than those of maturer age. The influence of climate on the amount of food required is probably over-estimated. Too much importance is attached to heat production by disregarding the fact that man adjusts the temperature of his body to that of the surrounding medium, not by increasing or diminishing the amount of heat he produces from food, but by the regulation of heat lost by means of clothing. In very cold climates the demand for heat is so great that it cannot be met by diminishing loss; the deficit is made up by an increase of heat production by a greater consumption of food, particularly fatty food. Similarly, in hot climates the demand for heat is so small that it can no longer be adjusted by an increased loss; in this case man instinctively avoids the nitrogen-containing foods and the fats, or those nutritive constituents from which a large amount of heat can be produced in a short time, but

the proportion of vegetable food-stuffs is relatively increased.

The foregoing is the very grammar of food-supply, which should be grasped by every officer and, through him, by every non-commissioned officer and man. The essential points to be understood are: (1) That classes of food have predominating but not exclusive qualities, and (2) that they should be combined differently for different places and duties; (3) That to live wholly upon one form of food puts a strain on the system in ridding itself (excreting) of the surplus of one element consumed while securing enough of another; (4) that in cold climates fuel foods must be freely used; (5) that in hot regions the starches and sugars are chiefly, not alone, required, their ratio to the nitrogenous group depending upon the muscular work demanded; (6) that in temperate climates a mixed diet, varying with season and duty, should be supplied and consumed.

Every one should understand that the ration, as consumed, is not a monotonous dole, but is a supply, variable in composition but consistent in nutritive value, designed to fulfil by authorised substitution all the requirements of a dietary for an active life. Further, it must be remembered that all weights of food, except bread, are those of the uncooked items; that bread, for instance, is weighed cold, when it is lighter than when first baked; so, again, meat is not issued in individual rations for the respective men, but in bulk, as quarters or joints to companies or considerable groups. The available carcass from an animal is rather more than half the live weight in good cattle, and may be less than half when the meat is poor. There is further loss from

the bone, and a still further shrinkage in cooking; this is especially the case in respect of vegetables, apart from their necessary loss in preparation. Every officer should know that salted or preserved meat has a lower nutritive value than an equal weight of fresh meat, with the exception of bacon. For these reasons the continuous issue of salted or preserved food is to be discouraged, a suitable flesh issue being secured as frequently as possible. To meet this difficulty scales of equivalents are laid down for guidance.*

It should be ingrained as a part of company, squadron, or battery administration that, if they are to be efficient soldiers, the men must be carefully fed; not simply to have enough food issued, but that it be in a condition to be consumed with relish. To this end every officer should understand the principles of cookery, of which cooking is the application. Given opportunity, an officer should familiarise himself with practical detail, exercising his interest in the cooking of the company kitchen with diplomacy rather than inconsiderate meddlesomeness. Associated with this, every officer should understand and personally interest himself in the administration and working of the messing funds. This is no perfunctory duty to be deputed to a non-commissioned officer; a poor table is not infrequently reflected in the sick report, as well as by indifferent service from men who are not technically sick. Similar practical interest should be shown in the control and nature of eatables sold to the men within and on the outskirts of camps and lines; these observa-

* "Field Service Pocket-book," 1907, p. 43. See also "Allowance Regulations," section 2.

tions refer more especially to pies, sausages, fish, cakes, and fruit. Needless to add, perhaps, the source and character of milk-supplies hawked in the lines require as much control as those of water.

The ration of the British soldier is obtained from the following sources in *peace*-time: (1) From the Government a free issue of 12 ounces of meat and 1 lb. of bread daily at home garrisons, and of 1 lb. of meat and 1 lb. of bread when serving in India or other places abroad. (2) A messing allowance of 3*d. per diem* towards the purchase of supplementary articles, such as extra bread, butter, potatoes, cheese, milk, vegetables, tea, sugar, &c. This money the soldier does not handle as cash; in fact, he never sees it. This daily allowance is a credit issue which is "pooled" or thrown into a common messing fund and administered by company and squadron officers for the supplying daily to the men of such articles as they themselves may desire. The men are grouped into messes, and each day through their non-commissioned officers draw in kind, according to their tastes, against the common fund. This system, introduced in 1900, has been an unqualified success, giving to the soldier not only a sufficiency of food daily, but a variety in accordance with his actual fancies. Of course it entails some administrative care and trouble, but with the non-commissioned officers and men co-operating heartily the labour involved is negligible. (3) In addition to the above, the soldier makes individual purchases either at the grocery bar or regimental shop or from purely civil sources.

The nutritive value of the Government issue in kind

is easy to calculate; on the home scale it is 1515 Calories, and on the Indian or foreign scale it is 1636 Calories. To make an estimate of the dietetic value of the food which the soldier obtains from the other two sources there are obvious difficulties. But, as illustrative of what the soldier actually does consume daily, the following three dietaries are instructive. Two were issued and consumed by men belonging to different corps in Aldershot; the third represents an actual day's consumption by a soldier in India. These three dietaries may be taken as typically representative of the food of the British soldier. It will be understood that included in the details are the Government issues of meat and bread; these are incorporated and worked up into the various dishes, which are rendered available by the supplementary issues obtained through the messing fund.

Diet A (Aldershot).—Breakfast: Fried liver, 6 ounces; bread, 6 ounces; tea; sugar. Dinner: Beef, 5½ ounces; pease soup, 7 ounces; potatoes, 16 ounces; bread, 5 ounces. Tea: Bread, 4 ounces; dripping, 1 ounce; tea and sugar. Supper: Porridge, 2 ounces; sugar. The nutritive value of this man's food for the day was estimated to be 2909 Calories.

Diet B (Aldershot).—Breakfast: Fried bacon, 3 ounces; bread, 7 ounces; tea; sugar. Dinner: Meat, 5 ounces as Irish stew, including haricot beans and lentils, 1½ ounce; potatoes, 10 ounces; bread, 5 ounces. Tea: Bread, 4 ounces; jam; tea and sugar. Supper: Fish and potato pie, 8 ounces. This man's diet was estimated to be equal to 3116 Calories.

Diet C (India).—Breakfast: Bacon, 3 ounces; two eggs; bread, 4 ounces; tea and sugar. Dinner: Beef, 5½ ounces; Yorkshire pudding, 4 ounces; potatoes, 8 ounces; bread, 4 ounces. Tea: Currant cake, 5 ounces; tea and sugar. Supper: Curried fish, 4 ounces; bread, 3 ounces. This man's diet was calculated to be equivalent to 3090 Calories.

In all the above dietaries the weights refer to cooked food, and as actually eaten. No allowance has been made for the nutriment contained in beer or other drink taken by the men. It will be seen that, taking these three men's diets as typical of the kind and variety of food which the soldier gets in a well-administered corps during peace-time, the average soldier is remarkably well fed. It will be readily understood that there are great variations; some men are by nature small eaters, just as others are the reverse. The general quality of the food supplied in our army is high. The issue of tinned meat is now practically discontinued in peace; at most it constitutes an issue once a week. The main criticisms which can be made on the feeding of the British soldier have reference less to the quality of the actual food than to the manner in which the men are often compelled to eat it. In barracks of recent design, where dining-halls are provided, these comments do not apply; but in places where the food has to be eaten in the barrack rooms there can be no doubt the sanitary conditions are verging on the undesirable. Apart from this criticism, another grave defect in the feeding of the soldier is the timing of his meals. Food should be taken with regularity and at proper periods. In civil life the prevailing custom is for three meals to be taken during the day at intervals of about five or six hours' duration. The official meals of the soldier are three, namely, his breakfast at, say, eight o'clock, his dinner at 12.30 in the midday, and an evening meal.* In spite of this, for practically eighteen hours the

* "King's Regulations," 1908, para. 1159.

soldier depends upon more or less personal or non-official sources for his food. Unless he provides himself with a supper or evening meal, he starts his day having had no food since the previous midday, except some weak tea and what he can have saved from dinner. To make up for this void, the temptation is great to fill himself with beer during the evening, and under circumstances when any alcoholic drink is bound to have its maximum intoxicating effects. Another vicious custom is that of opening canteens before the dinners are served; this tempts men to drink beer on empty stomachs, fill themselves with liquid, and, by so doing, not only lose their desire for solid food, but impair their ability to digest it. The remedy lies in educating the soldier up to the custom of taking his chief meal at sundown, or, say, at five to six o'clock, instead of at midday. If this were done there would be far less drunkenness at night and greater ability to sustain fatigue in the early part of the following day. The midday meal might well be limited to an official issue of bread and cheese with beer—practically corresponding to the usual custom of the artisan class in civil life. Some may say the soldier would not like this arrangement—he prefers his dinner in the middle of the day. If any one will trouble to make inquiries it will be found that a very large number of men would welcome the change. The chief objections will come from cooks and others desirous of closing the working day early. It is hoped that the time is not far distant when units will give this suggested change of dinner hour a trial. The other reform required is the insistence of the dinner beer

being drunk with the meal, and not before it. We all know that enormous improvements have been made in recent years in the feeding of the soldier and the fostering of a higher sense of luxury and decency at meal-times in barracks, but there is room for further change, and we cannot urge too strongly that it should develop on the lines indicated—namely, that the dinner should be taken in the late afternoon or early evening, and that beer from the canteens should be drunk in the middle of the day only with food.

In India and some foreign garrisons where food is cheap and the soldier has fewer opportunities for spending money than at home the danger lies in the men getting too much rather than too little food. In the hotter seasons the paucity of fresh vegetables is often a factor conducive to indifferent well-being; but the greatest danger to the soldier in India by means of his food is the ubiquitous presence of cook-boys and other low-caste natives in and about the lines. It would be far more conducive to clean food if the men cooked it themselves, and if the cook-houses in these barracks were planned and equipped in accordance with European practice, and also were fewer in number. The difficulty in all tropical or warm climates is the excessive presence of the common fly, which settles indiscriminately on food or fæces. For this reason the greatest care needs to be taken to protect food and cook-houses from their presence; this can only be done by elaborate precautions to close all doors and windows with fine wire gauze.

In time of war or for active service in the field a special ration is fixed by the Secretary of State,

according to the climate and the circumstances of the expedition. The following scale is adopted as far as possible: 1 lb. fresh, salt, or preserved meat; $1\frac{1}{4}$ lb. bread, or 1 lb. biscuit, or 1 lb. flour; $\frac{1}{2}$ ounce tea; $\frac{1}{3}$ ounce coffee; 2 ounces sugar; $\frac{1}{2}$ ounce salt; $\frac{1}{36}$ ounce pepper; $\frac{1}{2}$ lb. fresh vegetables, when procurable, or 1 ounce compressed vegetables; also $\frac{1}{2}$ ounce lime-juice with $\frac{1}{4}$ ounce sugar, and $2\frac{1}{2}$ ounces rum, when ordered by the general commanding, on recommendation of the principal medical officer.*

The ration issued to men in South Africa, 1899–1902, was in accordance with the same scale, supplemented, when occasion offered, by such issues as jam, cheese, and pickles; but all experience shows that no reliance can be placed upon any special scale of ration laid down. So many contingencies may arise to prevent adherence to it that it really constitutes but a standard with which the supply service will do its best to comply. If anything, our standard for a field service ration errs on the side of excess of nitrogenous food in an unassimilable form. The issue of so much meat in the preserved and concentrated form is a mistake; 8 ounces of uncooked preserved meat is ample. The notable prevalence of the two extreme conditions of constipation and diarrhœa among soldiers on field service rationed on the foregoing scale is explicable to a large extent by the indigestible nature of the meat element. It is a familiar fact to many that the great craving among men who have been a month or six weeks on such a field ration is for sugar, starch, and fat, in the form of jam, sugar, bread, and butter. A

* "Allowance Regulations," para. 27.

critical consideration of our field service food indicates its concentrated nature, and the curious lack of mass or ballast to stimulate the intestine to normal action. In practice the meat is canned and the bread is represented by biscuit; theoretically they may, and do, represent so much nitrogen and carbon, but potentially their calorific value is small, because the assimilation of the proximate elements is so difficult.

For rapid movements, when transport has to be reduced to a minimum, the use of concentrated and cooked foods is all-important. In these circumstances the use of pea and flour sausages, erbswurst, meat biscuits, and other forms of so-called emergency rations are the best to use. Various types of these preparations have been suggested, but in this connection we would urge that a greater consideration might be given to the fact that both cheese and bacon are articles of food of high nutritive value, and as both are everyday food-stuffs with the class from which the greater number of our soldiers are drawn it is not beyond the ingenuity of provision preservers to supply both in a form convenient for service needs. Our present emergency ration consists of a small tin cylinder divided into two compartments, and weighing 10 ounces. One compartment contains 4 ounces of pemmican and the other 4 ounces of chocolate paste.

The issue of a spirit ration on service has been the subject of much discussion; the whole experience of recent wars is against its issue. There is perhaps no point on which there is a more unanimous opinion than that there should be no daily issue of a spirit ration. But although the daily issue of rum as a ration should

be avoided, there are cases in which a ration of alcohol has been found to be productive of the greatest service, even where alcohol in the form of rum and beer may be productive of much evil. The advantage which light red wines possess cannot be passed over. These, well diluted, are most refreshing drinks in hot climates; they should of course be used in moderation, and for young and "unseasoned" soldiers probably total abstinence would be better. After a fatiguing march red wine may be given with advantage; it has a recuperating effect, and may possibly be a prophylactic against disease. Alcohol should never be allowed before or during a march, but at the end, and then only in the form already indicated. It was formerly supposed to be a preventative against malaria; that this is not so is now abundantly proved by the experiences gained in India and South Africa. There is no evidence to show that the issue of a daily ration of rum has been productive of any good, and in many cases it has certainly done much harm. On the other hand, light red wine may be given with advantage, as it contains a large amount of acid salts and tannin, which probably assist in destroying pathogenic bacteria.

Cooking of Food.—Apart from its power of removing any obnoxious property in a food by killing any disease germs or parasites existing in it, cooking so alters the texture of a food as to render it more easy of mastication and subsequent digestion. We may say there are six common methods of cooking, namely, boiling, roasting, broiling or grilling, baking, frying, and stewing. Though usually associated with meat, their essential principles are equally applicable to other articles.

Boiling has for its object either the extraction from the food of its nutritive principles or their retention in it. If we wish to extract all the goodness of meat into the surrounding liquid, as when we make a soup or a broth, the article should be cut up finely and placed in cold water. After it has thus soaked for a while heat is applied slowly; by this means the albumen of the meat is not solidified, but, with the other natural juices, flows out into the surrounding water, which gains in flavour and nutritive properties, while the meat itself is left as a hard, fibrous, and tasteless residue.

If, on the other hand, the object of boiling is not to extract from, but rather to retain in meat all its flavour and nutriment, then it should not be cut up, but left as a large piece, plunged suddenly into boiling water, and the boiling maintained briskly for five minutes. The application of sudden heat in this manner coagulates the albuminous matter on the surface of the meat, and makes an impermeable external coat which stops the escape of the juices from the inside of the meat. To complete the cooking, boiling should not be long continued, but the water allowed only to simmer. Cooked in this way, the central part of a joint of meat remains juicy and tender. Similar principles of trying to retain the soluble constituents of a food within it are involved when potatoes are boiled in their skins; but in the case of potatoes peeled and boiled, the soluble constituents escape into the surrounding water. Speaking generally, boiled food is less tasty, but more digestible than when cooked in any other way.

Roasting is conducted on the same principles as boiling, namely, the retention of the nutritive juices of

meat by the formation of a coagulated layer on the surface. After a short exposure to a sharp heat the meat should be removed to a greater distance from the fire; in this way the albumen is coagulated without the real tissue of the meat being hardened. The act of roasting is much hastened by *basting*, or enveloping the joint in a varnish of melted fat; this prevents undue loss of juices by evaporation and helps to close the surface pores of the meat. Roast meat is usually more savoury but less digestible than boiled. Too often baking is resorted to, and miscalled roasting; they are not identical. The average loss on roasting is from 31 to 35 per cent. in weight.

Broiling or *grilling* is the same in principle as roasting, but the scorching of the surface is greater, owing to the larger surface exposed to heat. *Baking* is analogous, except that the operation is carried on in a confined space, such as an oven. Owing to the limited space and want of ventilation in the chamber or oven in which baking is carried on, the condensed vapour from the article being cooked and the fatty acids, if it be meat, are prevented from escaping, rendering the food so cooked richer and stronger for the stomach. For these reasons baked food is unsuitable for the sick and delicate. During baking a joint of meat will lose from 20 to 30 per cent.

Frying, speaking generally, is a bad way of cooking, as, owing to the heat being applied through the medium of fat, the article so cooked is penetrated with oily matter, and is often indigestible. In frying the heat is applied usually much above that of boiling water, as the medium, fat, can be heated much above 212° F. before

it boils; and it is probably owing to the difference of temperature to which fish is subjected in the two processes that causes the distinction between a boiled sole or mackerel and a fried one. Over and above this, their difference may be due to the fact that the flavouring juices are retained in the flesh of the fried fish, while more or less of them escape into the water in which they are boiled.

Stewing is really a modification of boiling for extracting from food more or less of its juices, but if properly carried out the water should never boil, but remain at about 160° F. or so. Stewing is best conducted by means of a water-bath or *bain-marie*. Stewing places food in a favourable state for digestion. If properly carried out, a large part of the nutritive matter passes into the surrounding fluid, but owing to this fluid never having reached the boiling-point the residual meat is left soft, and not tough, as when allowed to boil for any time. The meat and the water in which it has been cooked are usually consumed together. Hashing is the same thing as stewing, only the meat has been previously cooked instead of being fresh. In cooking meat loses quite one-fourth of its weight, and in the case of articles which contain much water the loss is usually much more than this.*

Clean Food.—It is needless, perhaps, to say that all utensils used in cooking or holding food should be scrupulously clean, and carefully scalded and cleansed after each time of use. This is a matter largely connected with both personal cleanliness and the provision

* The reader should consult the "Manual of Military Cooking" for further information.

of clean air and cleanly surroundings. The following rules should be observed: (1) No food should be stored or kept in barrack rooms or wards. If it must be so kept there, it should be kept in a covered jar or other receptacle. (2) The hands and clothes of all persons who handle food or cooking utensils should be scrupulously clean. (3) All bread and meat stores should be kept scrupulously clean, tidy, ventilated, and not only free from, but rendered inaccessible to flies. (4) The kitchens and all fittings, such as tables, safes, shelves, as well as cooking utensils, should be clean. Cooks and their assistants must be personally clean, and wear clean washable over-clothing. As flies carry minute portions of filth and germs on their feet, contaminating all they touch, they should not be allowed to gain access to kitchens. (5) Mess orderly-men should be personally clean, and supplied with a sufficiency of towels for washing up. The general superintendence of washing up plates, dishes, and other articles employed in the serving of food to men might well be delegated to the men of the regimental sanitary squad.

Diseases connected with Food

The diseases connected with food form, probably, the most numerous order which proceeds from a single class of causes; and so important are they that a review of them is equivalent to a discussion on diseases of nutrition generally. It is, of course, impossible to do more here than outline so large a topic.

Diseases may be produced by alterations in quantity, by imperfect conditions of digestibility, and by special characters of quality.

Excess of Food.—In some cases food is taken in such excess that it is not absorbed ; it may then undergo chemical changes in the alimentary canal, and at last putrefy. Dyspepsia, constipation, and irritation, causing diarrhœa which does not always empty the bowels, are produced. Sometimes the process of absorption goes on too rapidly for assimilation ; in these cases the surplus products of digestion are got rid of by the kidneys. Familiar instances are transient albumen in the urine following an excessive input of nitrogenous food, or temporary appearance of sugar in the urine after an extravagant consumption of starches or sugars. The general results of habitual over-feeding are more insidious. If it be an excess of fat or starch and sugar, the surplus is stored up in the form of fat. In the case of nitrogenous food such storage is unusual except in the young. The usual fate of any excess of nitrogenous food is that it is split up into a carbon moiety, which is converted into and stored as fat, and a nitrogen-containing part, which results in cleavage products of a more or less toxic nature, and possibly concerned in the production of such conditions as gout and rheumatism.

Deficiency of Food.—The long catalogue of effects produced by famine is but too well known, and it is unnecessary to repeat it here. But the effects produced by deficiency in any one of the four great classes of aliments, the other classes being in normal amount, have not yet been perfectly studied.

If the deprivation of nitrogenous food be prolonged the body gradually lessens in activity, and passes into a condition which predisposes to the attacks of all the

specific diseases (especially of tuberculosis, typhus, and of pneumonia).

The deprivation of starches can be borne for a long time if fat be given, but if both fat and starch be excluded, though nitrogenous food be supplied, illness is produced in a few days.

The deprivation of fat does not appear to be well borne, even if starches be given, but the exact effects are not known. The great remedial effects produced by giving fat in many of the diseases of obscure malnutrition prove that the partial deprivation of fat is both more common and more serious than is supposed. In all the diets ordered for soldiers, prisoners, &c., the fat is greatly deficient in every country. The deprivation of the salts is also evidently attended with marked results, which are worthy of more attention than they have yet received.

Scurvy.—Closely connected with the subject of food and dietetics is the peculiar state of malnutrition called scurvy. This is now known not to be the consequence of general starvation, though it is doubtless greatly aided by it. Men have been fed with an amount of nitrogenous and fatty food sufficient not only to keep them in condition, but to cause them to gain weight, and yet have developed scurvy. The starches also have been given in quite sufficient amount without preventing it. The weight of evidence suggests that it is to the absence of some of the salts in food that we must look for the cause. For these reasons the theory and practice of preventing scurvy has for many years followed the lines of including in the dietary fresh vegetables and fruits, for the sake of the organic acids

and salts which they contain. The success following the routine administration of lime-juice to those unable to obtain fresh fruits and vegetables has emphasised the correctness of this view regarding the causation of scurvy, but more recent experiences throw doubt upon the idea whether the etiology of the disease is dependent absolutely on a lack of vegetable food. It is well known that many outbreaks of scurvy have occurred among expeditions which were well equipped with vegetable food. An analysis of all the evidence, coupled with our own experience, warrants the view that the dominant factor associated invariably with outbreaks of scurvy is the prolonged consumption of preserved food, both animal and vegetable. Such food undergoes in the course of prolonged keeping changes of a fermentative or analogous nature, in consequence of which the neutral organic salts are changed and possibly toxic products formed, and it is the ingestion of these substances which affects the alkalinity of the blood. These deleterious bodies are not due to putrefactive or bacterial decomposition, nor do they reveal themselves by any change obvious to naked-eye inspection. They may be well summed up in the term "devitalised food." This devitalisation or material departure from the fresh condition may be the result equally of faulty preservation, caused by exposure to undue heat, as to prolonged keeping. In other words, the more the constituents of a dietary depart from the fresh condition, and the more prolonged the period over which the consumption of such devitalised food extends, the greater are the probabilities of a development of scorbutic symptoms among the consumers. These considerations have an impor-

tant bearing upon the issue of tinned and other preserved foods issued to soldiers on field service. Not only should these be obtained from the best makers and their manufacture be open to official inspection, but old stocks should not be accepted or issued. All tins need to be carefully inspected, and all showing signs of "blowing," due to production of gas within them, must be rejected. It would be as well if tins containing preserved food were always stamped with date of manufacture. Having been accepted, tinned or preserved food must be stored in reasonably cool places, and not exposed to a tropical sun or other conditions associated with high temperature; to do otherwise offers a premium on rapid decomposition and retrograde changes in the food itself, which must lead to sickness among those consuming it.

Notes on Individual Items in the Food of the Soldier

The following summary may be of practical value, dealing as it does with the more important sanitary features associated with the commoner articles of food.

The Meat Issue.—This constitutes the most important item in the daily food of the soldier. Meat is one of the few articles of diet on which life can be supported alone for any length of time. It is not, however, a perfect food, being relatively too rich in nitrogen and too poor in other nutritive elements. The relative nutritive value of different meats depends on the amount of fat they contain, which replaces part of the water of the leaner meats. The chief mineral substances found in meat-juice are phosphoric acid and potash, together

with certain soluble matters known as extractives. The exact chemical nature of the extractives is still largely unknown, but they appear to have no nutritive value, and are of importance chiefly as the cause of the characteristic taste of meat. The chemical composition of meat varies, depending much on the part or "cut," as well as upon the breed of the animal and the degree to which it has been fattened. About 15 per cent. of ordinary butcher's meat is made up of bone, gristle, tendon, and other parts which are inedible.

Officers and others should have a working knowledge of the appearance of not only wholesome dead meat, but of live animals intended for slaughter. The usual conditions of contract for the Army demand that live oxen and sheep shall not be under two nor more than five years old; heifers and cows must not be under two nor more than four years old. The most suitable animals for military purposes are those which are moderately fat. Very fat animals are wasteful in cooking, and as much to be avoided as those which are thin and under-fed.*

The condition of live cattle is generally told by the handling points, of which as many as twelve are given, but only five need be mentioned, as an animal which is good in these five points is sure to be good in the rest. They are the natches, or the bones by the side of the tail, the twist, the flank, the cod or udder, and the rib. The flesh on all these handling points should feel compact and firm, the twist or parts between the two buttocks should stand prominently out, the flank should

* Much useful information on this subject can be gathered by a study of the "Supply Handbook for the Army Service Corps."

appear to meet your hand and drop into it as you handle the animal, the rib should be well covered with compact flesh, and the cod or udder should be a large lump of firm fat. In half-fed animals the flesh will not be so firm to the touch as in fully fed ones; the meat of such half-fed cattle wastes very considerably in the cooking, owing to the cells of the adipose tissue being filled with imperfectly formed fat. To be able to tell the condition of a beast by handling requires some practice.

As showing health, we should look to the general ease of movements; the quick, bright eye; the nasal mucous membrane red, moist, and healthy-looking; the tongue not hanging; the respiration regular, easy; the expired air without odour; the circulation tranquil; the excreta natural in appearance.

When sick the coat is rough or standing, the nostrils dry and covered with foam, the eyes heavy, the tongue protruded, the respiration hurried, movements slow and difficult; there may be diarrhœa, or scanty or bloody urine, &c. In the cow the teats are hot.

The more important diseases common to cattle and sheep are as follows:

Anthrax.—The symptoms of this most contagious and infectious disease are lowering of the head to the ground, occasional shivers, often looseness of the bowel, with frothing from the nose and mouth. After slaughter, animals so affected will be found to have the intestines half filled with a black fluid; small blood-spots of the size of a pea will be found on the carcass and on the lungs. On cutting into the flesh it is very light in colour and looks parboiled.

Foot and mouth disease is characterised by lameness and the presence of blisters at the junction of the hair with the hoof, by slobbering at the mouth, inability to chew food, blisters on the tongue, on the pad, and on other parts of the mouth.

Pleuro-pneumonia is difficult to detect in the living animal, unless the disease is far advanced, when the laboured breathing is both marked and suggestive. On slaughtering, the lungs have the appearance of red granite and sink in water. A grey-granite appearance of the lungs indicates "bronchial pneumonia."

Dropsy is indicated by a watery swelling under the jaw or in the dewlap. Dropsical meat is pale in colour and flabby to the touch.

Tuberculosis.—This is a very common disease among cattle, especially cows. The symptoms are cough, laboured breathing, looseness of the bowels, wasting of the flesh, and often tenderness and swelling of the udder. After death, grape-like nodules will be found covering the inside of the chest, and occasionally that of the abdomen. They will be seen also in the lungs and in the various glands. A rarer form is almost entirely limited to the lungs; in this type the nodules are like millet seeds, and clustered together. Tuberculosis in cattle is identical with the corresponding disease in man.

Fluke-rot.—Sheep are frequently afflicted with a parasitic worm in their livers, known as the "fluke." In advanced cases the animals are weak and anæmic. On slaughtering, the flesh is sodden, dropsical, and blanched.

A great number of other diseases attack cattle and

sheep which it is not necessary to enumerate. All the above are tolerably easy to recognise during life, but the presence of various parasites and worms in their flesh which give rise to similar worms in man can usually be detected only after death. Obviously diseased animals should not be slaughtered for issue as meat. Certainly the flesh of animals suffering from anthrax, foot and mouth disease, pleuro-pneumonia, and dropsy is quite unfit for issue. The same must be said of animals in an advanced stage of tuberculosis or fluke-rot. Where these latter diseases are limited or in an early stage, provided the obviously diseased parts are rejected and destroyed, there is reason to believe that the other portions of the carcass are fit for human food, assuming in all cases that cooking is efficiently carried out.

Meat, on inspection, should be firm and elastic to the touch, of a bright, glistening, uniform colour, and slightly mottled from the interspersion of fine lines of fat with the lean. The odour should be faint but pleasant, the juice reddish, and the fat firm, yellowish in colour, and free from blood stains.* Excessively fat meat should not be accepted unless the contractor removes all surplus fat. In beef, surplus fat is the excessive fat at the kidneys, pelvic cavity, cod fat, and udder; in mutton, that on the back and in the region of the kidneys. If the kidneys are removed the kidney fat must also be taken out. Beef should be issued in quarters, the bone from four inches above the knee and upper hock-joint to be either excluded or allowed for

* See "King's Regulations," 1908, para. 1162; also consult "Guide to Meat Inspection for Regimental Officers."

in weight. The weight of meat should be taken after it has hung for a time not exceeding forty-eight hours, and an allowance of 1 per cent. deducted to cover losses of cutting up. The usual practice in the Army is to issue beef on six days and mutton on one day in the week. The beef on four days in each week must be fresh; frozen beef may be issued on the other two days. Mutton may be frozen. Frozen beef or mutton is not supplied to hospitals without the written approval of the commanding medical officer.

Frozen meat can be distinguished easily before it is thawed by its cold, hard touch; the fat is not stained. When frozen meat has been thawed the outside will have a wet or parboiled appearance, and there will be oozing and dripping of liquid from the meat. The fat is of a deadly white colour. The flesh has a uniform pink appearance, owing to diffusion of the colouring matter of the blood, and on a fresh section being made the watery condition will be very apparent. This loss of juice must be more or less deteriorating to its quality.

Horse-flesh can be detected often by the fact that the horse has eighteen pairs of ribs, while the ox has only thirteen pairs. The tongue of the horse is smooth at tip and base; the ox's tongue is rough. The flesh of the horse is much darker in colour and coarser in fibre than that of the ox, and the bones are heavier than those of the ox. The whole of the fat of the horse is oily, yellow, has a disagreeable flavour, and is separated from the lean. The odour of the meat is different from that of beef.

The flesh of a goat is dark, harsh, and strong, with a

peculiar goaty smell. The shanks of the fore and hind legs are very thin, ribs white, outer coating of carcass deep red; neck very thin in nanny-goat, and very thick in the he-goat.

The general quality of meat issued to soldiers is undoubtedly good, and we have no reason to think that under existing conditions any ill-health results from its issue. Though this is the case, it behoves all inspecting meat rations to critically note the quality of this food. Mention has been made of the fact that the flesh of animals may be infected by certain parasitic worms. It is impossible to detect these during life, and not always easy to do so after death. When present, the parasites will be found as small cysts or bladders in the muscular flesh. These cysts are intermediate stages in the life-history of various worms, particularly tape-worms, which adult form is assumed as soon as the cyst has reached the bowel of the consumer. The flesh of oxen and pigs is particularly liable to this form of infection, known colloquially among slaughtermen as "measles." The cysts, if large, are visible to the naked eye as small round bodies; when examined under a low power their real nature is seen. They may be so numerous as to cause the flesh to crackle on section. Pigs are further liable to infection by small worms, which lie coiled up in encapsuled cysts in the flesh. These worms, if consumed by man, can give rise to troublesome symptoms. Their occurrence is rare in our service. Fortunately efficient cooking destroys these various forms of parasitic worm, if present in animals used as meat.

In all garrisons, power is reserved to issue preserved

meat from the Government stores whenever thought fit. Such issues are limited, as far as possible, to one issue per month, and are in place of fresh beef. Tins of preserved food must be considered as unfit for issue when perforated by nails; when there are any angular indentations which are likely to have caused partial fracture to the tin and rendered it liable to rust; when they contain gas and are bulged or blown; when they are rusty, or when the lacquer has worn off the tins; when it is found that the tin does not adhere closely to the contents, or when it is evident that the tin has not been hermetically sealed or soldered, and that the ontents have either dried or putrefied.

The Bread Issue is made in 2-lb. loaves, the same being delivered not earlier than twenty-four nor later than forty-eight hours after baking. In checking weights of bread, single loaves should invariably be weighed. Good bread should be light and flaky, the crumb breaking between the fingers, and when fresh should be elastic and resume its place after light pressure with the hand. No part should be without small cavities; these are due to the expansion of the carbonic acid gas generated from the flour during fermentation.

The crust should be of a rich brownish-yellow tint, not burnt, but as thin as possible so far as is consistent with sufficient baking. The crumb should be cream-white in colour, and sweet to the taste. If bread be acid, badly risen, or of a yellowish colour it may be owing to old or fermented flour, or bad yeast, or to the use of sour and dirty troughs. On the other hand, when bread is unnaturally white, light or brittle, alum or some other chemical may be suspected. Bread

which is very compact and briny is probably "salt-bound." If the loaf is large but wanting in firmness and insipid in taste sufficient salt has not been used. Among many causes which may lead to the bread being sodden and heavy are the use of inferior flour or bad yeast, the dough being insufficiently kneaded, working with too fierce an oven or an oven not hot enough, or piling loaves of hot bread one on top of another. One of the commonest defects in contract bread is under-baking, which retains an excess of moisture in the loaf and so adds to the weight. The use of potatoes in making bread, also alum, is not so common now as formerly. Potatoes are objectionable as lessening the nutritive value of bread, and also tending to make it go sour. The use of alum is to conceal the employment of old or inferior flour.* Bread should be stored in cool, dry, and well-ventilated rooms, with the racks so placed that air circulates round the loaves. Not more than two layers of loaves should be placed on each shelf in the rack. If the store is badly ventilated moisture is retained and the bread is heavy. Bread is the main source of starch in the soldier's dietary; it is practically devoid of fat, hence the universal practice of eating it with either fat, dripping, or butter.

No diseases among soldiers can be attributed to the consumption of bread. In its preparation the chief sanitary risks attach to the use of dirty flour, dirty ferment, and dirty troughs. These are details which need supervision in bazaar bakeries in India.

Eggs offer a convenient and concentrated article of

* Consult "Supply Handbook for the Army Service Corps," p. 53 *et seq.*

diet, rich in fat and nitrogen, but apt at times to be indigestible, particularly if over-cooked. They do not enter largely into the soldier's diet, owing to their cost. Their condition as to freshness is determined readily by dissolving two tablespoonfuls of common salt in a pint of water; in this saline solution a good egg will sink, while a stale or bad one floats.

Milk is not much consumed by soldiers, except in tea or coffee. It is nothing more than an emulsion of fat containing a nitrogenous curd, with sugar and lime salts in solution. It is a typical food, all the constituents of a perfect diet being present. Milk tends to undergo rapid fermentative changes, especially in warm weather or when tainted with filth. These changes are due to the action of micro-organisms. For these reasons it is necessary to store milk in clean, cool places, and to keep it protected from the access of flies and dust. The chief adulterations of milk are the addition of water and the removal of cream. Milk drawn from tuberculous cows, if consumed in the raw state, can convey tuberculosis to the consumer. Similarly, milk diluted with dirty water or drawn from the udders of cows which have been lying in garbage may be the means of conveying cholera, enteric fever, dysentery, and infective diarrhœa. In some cases suspicion has attached to milk as a means of spreading both diphtheria and scarlet fever. There is no article of diet which requires the exercise of greater cleanliness in all its manipulations than milk.

Preserved milks, or rather concentrated or condensed milks, with or without sugar, are in common use by soldiers. The unsweetened brands keep less well than those with sugar, once the tin is opened. The observa-

tions made in regard to both the storage of raw milk and the inspection of tinned foods apply with special force to condensed or preserved milk.

Cheese is a very valuable article of diet, being rich in nitrogen and fat. The main defect is indigestibility. Its adulterations are unimportant. It is to be regretted that this food does not enter more into the daily dietary of the soldier, as it is highly nutritious, and one with which the class from which soldiers are drawn is eminently familiar.

Butter, or one of its substitutes, constitutes the main source of fat in all dietaries. In that of the soldier it occupies too small a space; this is largely a question of cost. It is highly nutritious, presents few sanitary risks, and practically only one common adulteration, namely, excess of water. The various artificial butters are probably quite as nutritious as genuine milk butter; they all practically contain 80 per cent. of fat.

Vegetables.—Potatoes are the chief vegetables eaten by soldiers, and, with bread, serve as his main supply of starch. If properly cooked they are highly nutritious, and, like onions, cabbages, &c., possess undoubted value, in the fresh state, as safeguards against scurvy. Among vegetables, the chief sanitary risks attach to those which are eaten raw, such as radishes, tomatoes, and watercress. These need to be scrupulously well washed in several relays of clean water, not only to remove ordinary earth, but also sewage and other objectionable elements derived from water in which they may have been growing. Not a few cases of enteric fever are traceable in the summer and autumn

to the eating of carelessly cleaned green-stuff of this kind.

Shell-fish.—Although not an item in the official diet of the soldier, these foods are largely eaten by soldiers, as the result of private purchases. In the form of whelks, periwinkles, mussels, and occasionally oysters, these are favourite dishes. Their casual consumption is not free from risk, as they may easily be the vehicles for the conveyance of germs of enteric fever, dysentery, diarrhœa, or even cholera. This arises from the fact that the laying-beds for these shell-fish are often located in tidal waters to which sewage gains constant access. If so, the results are intelligible. The remedy lies in a recognition of the fact, and the careful washing of the fish in several changes of clean water. If this be done the sewage material is ejected from the shells, and the consumption of these fish in the raw state more or less unattended with risk. The importance of attention to this point should be brought home to the soldier, who would then learn to exercise discrimination in the selection of places for the purchase of these delicacies.

Alcohol.—The main source of alcohol to the soldier is beer; only a few drink the ordinary spirits, brandy, whisky, gin, or rum. In all these beverages the essential dietetic element is alcohol, obtained by the fermentation of a solution of sugar. Regarded as a food, the nutritive value of beer is small, though, of course, higher than any other alcoholic drink, owing to the large amount of maltose, dextrin, and other saccharine substances which it contains. In the main its dietetic effects are those of alcohol, of which it contains about

4 per cent. Ordinary spirits contain from 40 to 50 per cent. of alcohol. On some people beer acts as a depressant, and if taken in excess is a stupor-producer and intoxicant. Beer also seems to exercise slight but continuous interference with tissue change, with a tendency to fatten and engender gout and rheumatism. When drunk to any excess beer has a retarding influence on digestion, and produces the same injuries to health as excessive indulgence in stronger alcoholic liquors; taken in moderation, however, particularly the lighter varieties, beer is an invigorating and refreshing beverage.

In attempting to understand the important, but somewhat difficult, question of the dietetic value of alcohol one must bear in mind that there is a distinction between the effects of alcohol taken in dietetic doses and when taken in excess, and, too, that the physiological action of pure alcohol is not quite the same as that of many alcoholic beverages, because many of these contain other bodies besides alcohol, which have a distinct action of their own. Moreover, it must not be forgotten that what is a dietetic dose for one person is an excess for another. Experiments indicate that when alcohol to the amount of $\frac{1}{800}$ part of the body weight is administered a bare 3 per cent. of that amount is excreted by the urine and breath, the remainder apparently being made use of in the body as a food. If double the quantity of alcohol be given some 10 per cent. is thrown off from the body unused. If a still larger dose be given, say equivalent to $\frac{1}{300}$ part of the body weight, rather more than 50 per cent. is excreted; in other words,

there is an absolute failure on the part of the body to utilise more than half of the quantity of alcohol administered. If the dose be still larger the amount rejected and unused amounts to three-fourths. Alcohol, therefore, in small doses may be regarded as capable of utilisation in the body as a food; but since when large doses are taken more than half is excreted unused, it cannot be considered a true food, and if taken to excess this contention applies with even greater force.

These experimental data compel us to say that one and a half fluid ounces of absolute alcohol in twenty-four hours is the maximum amount which a man should take. This is contained in about three ounces of ordinary brandy, whisky, gin, or rum; in three-fourths of a pint of the light wines, such as clarets and hocks; and in three pints of the ordinary ales or beers, such as soldiers drink. Any consumption over these amounts means the dosing of the body with a quantity of alcohol with which it is incapable of dealing. If so, it can do no possible good, but much real harm.

It is a popular idea that alcohol tends to make one feel warmer. On this point there is no evidence to show that it does anything of the kind; on the contrary, there is much to indicate that, if anything, when taken to excess, it really lowers the body temperature. Moreover, it is beyond question that the systematic consumption of alcohol tends to lower the natural resisting power of the body against cold, and for this reason alcohol is unsuited for those exposed to great cold. If taken too often, even in small doses, or taken in any large quantity at one time, alcohol, instead of stimulating the nervous system, actually depresses and

paralyses it, as evidenced by the condition of intoxication. In these circumstances the perceptive power of the brain is depressed or paralysed, correct judgment is impossible, while speech is disordered, and the emotions are out of all control. If repeatedly taken to excess alcohol delays digestion, causes catarrh of the stomach and bowels, accompanied by degenerative conditions of both the liver and kidneys, sufficient to result in death. It is beyond question that, when taken in sufficient quantities to produce these effects upon the brain and nervous system, alcohol causes an immensity of harm. The physical, moral, and social evils of intemperance are only too familiar.

How far alcohol is beneficial or not when taken in small or dietetic doses is still a matter of controversy between the teetotalers and those who advocate moderation. Of this, however, we are certain, that only under exceptional circumstances can alcohol be regarded as a food; also that a person can do quite as hard, if not harder, work without alcohol than with it. It does not appear possible at present to condemn alcohol altogether as an article of diet in health or to prove that it is invariably hurtful, as some have attempted to do. It produces effects which are often useful in disease and sometimes desirable in health, but in health it is certainly not a necessity, and the majority of persons are better without it. In ordinary life, to many the cares and worries of business and existence are such that to them after the labours of the day a moderate amount of alcohol in some form or other is not only an advantage, but almost a necessity. To the old and feeble the use of alcohol is not

less valuable. We are of opinion that these facts should influence our attitude in regard to the use of alcohol in the Army. Where men are known to habitually abuse the consumption of alcohol they should be encouraged and helped to become total abstainers, but where such is not the case it seems questionable policy to veto the consumption of alcohol altogether or to coerce men towards total abstinence. In all cases it is desirable that alcoholic beverages should not be drunk during working hours. The only time when alcohol can be advantageously used is after the day's work is over; so taken, its influence is often to check tissue change and waste, to soothe and stimulate an exhausted nervous system, with a removal of the sense of fatigue, and to promote digestion. Alcohol should never be taken fasting; its best effects are secured when taken with food, and at no meal more so than at the late dinner or supper. The only hope of a more rational use of alcohol by soldiers lies in the inculcation of sound knowledge as to its dietetic value.

CHAPTER XI

CLOTHING, EQUIPMENT, AND WORK OF THE SOLDIER

The essential requirement of clothing is that it should maintain a uniform and equable temperature in all parts of the body. The average temperature of the surface of the body is 98·5° F., and the maintenance of this temperature is an essential condition of health and comfort. The factors governing the body temperature are (1) the amount of heat produced, and (2) the amount lost. The source of all the heat produced in the body is the food taken, while heat is lost from the body by the skin, by the breath, by the excreta, and by the transformation of heat into mechanical energy. Of the whole loss by these channels probably 85 per cent. is through the skin. When the external warmth is considerable increased evaporation from the skin occurs; while when the weather is cold the surface blood-vessels contract, and less blood goes to the skin, and so the loss is diminished. In most climates, however, this action of the skin requires to be supplemented by some kind of clothing.

Clothing of the Soldier.—In selecting the material for soldiers' clothing the chief points to be considered are the property it has of conducting and

absorbing heat, its permeability to air and water, and its durability. The amount of heat radiated from dress will depend on the rapidity of heat conduction from the skin. The amounts of conduction and radiation of heat will vary considerably with the material and colour of the clothing. As regards *conductivity*, the two extremes are represented by linen and fur. Experiments show that if the heat-conducting power of linen be 100, then that of wool is 60. This explains partly why woollen goods are so much warmer than linen. As regards *radiation*, experiments indicate that while a piece of linen may take 10 minutes to cool, a corresponding piece of flannel takes $11\frac{1}{2}$ minutes. Apart from the material, *colour* has some influence in regulating the loss of heat. Dark-coloured materials absorb more light and heat than lighter-coloured fabrics; they may be good or bad conductors of heat, according to the nature of the material. White reflects light and heat rays; hence it is a poor absorber. In summer, white clothing prevents the passage of heat inwards, and in winter may prevent its passage from the body. Next to white, the least heat-absorptive colour is grey or pale yellow; following this come in an increasing degree dark yellow, light green, red, dark green, light blue, and black. The influence of colour is, of course, antagonised to a large extent by the nature of the material; the increased heat absorbed by a dark material may be counterbalanced by the material being a good conductor. Also, the influence of colour is exerted only superficially; hence, although it produces considerable effect in thin textures, it has little influence on thick materials.

Clothing should not interfere with perspiration. In order that it may not do this it should be able to absorb moisture easily without its surface becoming wetted. Materials, like cotton and linen, which lose their porosity and rapidly become wetted by perspiration cause rapid loss of heat from the body, inasmuch as water is a better conductor of heat than air. Experiment has shown that the maximum hygroscopic power of wool or flannel is 174, and the minimum 111; the maximum of linen or cotton is 74, and the minimum 41. Hence a flannel vest next to the skin involves a lesser liability to chill as compared with a linen one. There is this counterbalancing drawback: hygroscopic materials can absorb moisture from the air as well as from the skin; thus, a woollen coat during a damp day, without rain, increases considerably in weight. Waterproof clothing is injurious when worn beyond a short period, owing to its being non-porous and consequently keeping the body enveloped in a vapour-bath of its own perspiration. For similar reasons india-rubber boots are objectionable, except for short periods, as they make the feet damp, and even sodden. Leather and various skins or furs are objectionable for walking, not only because of their weight, but because they are not porous.

Cotton is durable, does not shrink when washed, is non-absorbent of moisture, conducts heat rapidly away, and has the effect of chilling the body if perspiration is present; hence it is not the material for the dress or under-garments of soldiers.

The disadvantages of woollen clothing are that the material becomes hard and shrinks on washing, and thus

loses in part its absorbing properties. Much of this is due to faulty washing, the mistake made being that too often the clothing is coddled, and not washed and dried quickly. If this be done the tendency to shrink can be much reduced. Often an excess of alkali in the soap used hardens the wool; this, however, is less a factor in shrinkage than washing in very cold or very hot water and failing to dry quickly. Soldiers' shirts are manufactured from a mixture of cotton and wool. This material is lighter and cheaper than pure wool, and is said to be more durable; it does not shrink in washing. There should not be more than 30 per cent. of cotton in the mixture.

As regards colour, probably grey is the best for soldiers' clothing. White is least suited for field work, as it soils so quickly. The khaki drill and serge appear to answer well, and as regards heat-absorption power correspond very closely to similar materials in grey.

The recruit on enlistment receives a free kit. Some of the articles the State replaces as they become unserviceable, others he is obliged to make good at his own expense. Clothing is divided into: (*a*) *Personal*, such as ankle-boots and shoes, caps, drawers, canvas suits, service dress suits, puttees, sashes, cardigan waistcoats, trousers, tunics, and leather gloves. These become the property of the soldier, and may be sold, in peace-time, by permission of the squadron, battery, or company officer. (*b*) *Public*, such as greatcoats, full-dress headdresses, knee-boots, leather breeches, jack-spurs, foreign service helmets, leggings, waterproof capes, purses and belts for Highland

regiments. These must be returned to store, and are the property of the public. (*c*) *Necessaries*, such as badges, laces, braces, blacking, brushes, button brasses, combs, cotton drawers, forks, gauntlets, worsted gloves, grease-tins, holdalls, hose-tops, housewives, knives, razors, polishing powder, shirts, socks, sponges, pipe-clay, spoons, swan-necked spurs, towels, and vests. On field service necessaries are issued free to replace losses not caused by negligence; in peace-time, after the original free issue of necessaries to the recruit, losses must be made good at the man's own expense. (*d*) *Sea-kit*, such as clothes bag, woollen belt, and marine soap.

In India and other tropical stations light clothing, either white or khaki colour, is used. For other stations abroad soldiers are supplied before embarkation with such new articles of personal clothing as needed, owing to differences of climate, pattern or scale. Similarly, before proceeding on active service the soldier is supplied with additional articles of clothing according to the circumstances of climate and season.

All clothing should be made to fit loosely, so as to allow free movement of every part of the body, otherwise mechanical work is increased. In the British Army the underclothing consists of shirts, stockings, and flannel belts. The shirts are made of a mixture of wool and cotton. In hot climates all wool would probably be found a better material; but the collar-band should be made of linen to avoid shrinkage, and consequently tightness round the neck. The socks are made of worsted; they shrink badly, and not a little

trouble results to the soldier owing to the misfitting and creasing which follows this shrinkage. They are a fruitful source of sore feet. The number supplied to the men might well be increased by another pair. Flannel belts are issued to the men for tropical service to protect the abdomen from chill. We question the utility of wearing these articles during the day; but if once worn they must be continued. To wear these belts intermittently is attended with great risk, as the chances of chill and consequent enteritis are much increased. These belts should invariably be worn when sleeping under a punkah or in the open air.

The tunic or full-dress coat of the British soldier is close-fitting, and to some extent interferes with the free movements of the chest. If loosely made it does not give the same appearance of smartness to the men. The coat worn on active service and for everyday work is cut looser, and, moreover, made of either serge or drill. The trouser should be cut full and wide over the buttocks and thighs; a common fault with soldiers is to get this garment to fit almost like a glove. This may look taut and smart, but it is inconsistent with free muscular effort. For active service and everyday work the trouser is largely replaced by breeches reaching to the ankle, fitting closely round the calf; the puttee, too, is worn with these, and also with the trouser. Puttees give support to the leg and protect it from bites of insects. These articles need to be put on carefully. In many mounted corps the puttee is replaced by the gaiter. For the suspension of the trouser or breeches braces are preferable to a belt round the waist. They

give better means of support, and do not compress any part, which a belt invariably must do. This latter is also said to predispose to hernia.

The greatcoat and cape is issued in three sizes, and weighs from 5 lb. 8 ounces to 6 lb. 3 ounces. It is made double-breasted, but seldom long enough. The cloth is excellent, but it is rather heavy, absorbs a large quantity of moisture, and is difficult to dry. It would be an advantage if the greatcoat could be made of a lighter material, and waterproof.

For service in the field a waterproof sheet is an imperative necessity, to protect against rain or ground moisture. The waterproof sheet should always be used to lie on, unless employed to form a temporary *tente d'abri*. Cloth may be made waterproof by the following simple plan: Make a weak solution of glue, and while it is hot add alum in the proportion of 1 ounce to 2 quarts. As soon as the alum is dissolved, and while the solution is hot, brush it well over the surface of the cloth, and then dry. It is said that the addition of 2 drachms of sulphate of copper is an improvement. Hiller describes a useful method of waterproofing porous materials, such as cloaks, &c., by dipping them alternately in a solution of sulphate or acetate of alumina and of soap.

Such articles as sheepskin coats, hoods, gloves, &c., issued for protection against very severe cold, are necessary, and are fully justified by the results following their use.

The headdress is an important article of the soldier's kit. The essentials of a good headdress are that it should be light, durable, and comfortable; that it does not press unduly on any part, nor fit too closely on the

head. It should admit of a limited amount of ventilation, and its shape should not only serve as a protection to the head, but it should afford as little resistance as possible to the wind. Helmets are now issued to infantry regiments, artillery, and engineers, and also to departmental corps. Bearskin caps are worn by the Guards, Highland bonnets and shakoes by Scottish regiments, and a sealskin cap by Fusilier regiments. The infantry helmet weighs 14½ ounces. It is made of cork covered with cloth. The weight of the bearskin is 37 ounces. The Highland bonnet weighs 18 ounces.

In the cavalry and horse artillery helmets are also worn, but of a slightly different pattern. They are of excellent shape, but rather heavy. In the Guards and Heavy Dragoons the helmet is of metal, and is partly intended for defence. The weight of the Life Guards' helmet is 55 ounces, and that of the Dragoon Guards 39 ounces. Were the helmet made of aluminium these weights might be considerably reduced. The Lancer cap weighs 29½ ounces, the Hussar busby 34 ounces.

In India the same headdress is worn by all the different branches of the service. Helmets made of bamboo or cork, covered with cotton and provided with pugarees, are now in general use; they are very light, weigh 13 ounces, and afford good protection from the sun.

The boots supplied to the soldier are in thirty-two sizes, made right and left, and weigh about 40 ounces. The sole is wide, and the heel low and broad. The personal supervision by officers of this issue to men is

of the first importance. The leather has to be of a certain quality, and a number of boots are always cut up and examined before a contract is passed. There must be eight stitches per inch for the upper leather, and the thread must be of a certain strength and well waxed. The great fault of this boot is its hardness and the rough way in which it is finished. Once it is moulded by wear to the shape of the foot it is an excellent boot. For its preservation Army Orders direct (1) that soldiers' boots are to be blackened with three coats of ordinary blacking instead of other substances; (2) boots or shoes in store are to be dubbed, or have neat's-foot oil applied to uppers at least once in four months.

Load carried by the Soldier.—The actual weights or load carried by the man, as well as the mode of carrying the weights, are matters of great importance, if good work is to be obtained from the soldier. In the cavalry and artillery the weight of the accoutrements and equipment is in great part carried by the horse. The cloak, when not worn, is carried either in a roll over the shoulder or in front of the saddle. Including the rider, the load of the average cavalry horse is at least 18½ stone.

Of late years the load carried by the infantry-man has been much reduced; in fact, on peace manœuvres he carries little more than his rifle, ammunition, greatcoat, and some food; his blankets and valise containing his necessaries are carried for him. The following is the personal kit and equipment for field service of the infantry soldier as issued in A.O. No. 71, of April 1904:

	lb.	oz.
Rifle, short, with sling	8	3½
Sword-bayonet, with scabbard.	1	4¾
Belt, waist, with four cartridge pouches. . .	1	9
Frog, for bayonet		4¾
Bandolier	1	2
Ammunition (100 rounds)	6	14
Haversack, containing bread or biscuit emergency ration, fork, spoon, and tooth-brush . .	2	14½
Mess-tin and cover, containing some ration . .	2	3¼
Water-bottle, filled, carriage and strap . . .	3	12
Tin of mineral jelly, pull-through and cover . .		8½
Greatcoat, with comforter and a pair of socks .	6	6
Headdress	1	2¾
Jacket, with first field dressing and description card	2	8½
Trousers (or kilt and apron, 4 lb. 5 ounces) . .	2	1
Jersey or cardigan	1	5
Braces		4½
Shirt, flannel	1	1½
Belt, woollen, and socks		8¾
Boots, ankle	3	14
Puttees or gaiters		14½
Clasp-knife and lanyard		8
Drawers, one pair	1	0½
Total	50	7¼

It has been the custom to carry a certain amount of spare kit for the soldier, contained in a canvas bag. This, which included a waterproof sheet, a blanket, and other articles, weighs 12 lb. A recent committee has advised that only the waterproof sheet and blanket be so carried, and that the following essential articles of spare kit—bootlaces, housewife, towel and soap, and pay-book—be carried by the man in addition to those given above. If possible, an extra flannel shirt is to be carried by the man. The result of this will be an additional load of 1 lb. on the man, or 2 lb. 1½ ounces if

he carries the shirt. The canvas shoes now carried for men are deemed a luxury, and will be carried for dismounted units to the extent of 5 per cent., and issued on medical recommendation only.

In the cavalry the weight carried seems excessive, the weight of clothing and equipment being nearly equal to that of the man himself. In the case of the infantry soldier, under modern conditions, the load is not excessive, though quite enough. Compared with what was carried in earlier times and even within twenty-five years ago, the load detailed is all in favour of the present-day soldier. Whatever load is carried by the man, the greatest care is necessary to so arrange the weights as not to detract from the man's efficiency or to injure his health. The chief points to attend to are to so adjust the weights that when carried they fall as near the centre of gravity as possible, and not outside it. In the upright position the centre of gravity is between the pelvis and the centre of the body, usually midway between the umbilicus and pubis, but varying, of course, with the position of the body; a line prolonged from this centre of gravity to the ground passes through the centre of the ankle. Hence weights carried on the head or top of the shoulders, or which can be thrown towards the centre of the hip bones, are carried easily, being over the gravity centre. If a weight be borne away from this line the centre of gravity is displaced, and, in proportion to the added weight, occupies a point more or less distant from the usual site, until, perhaps, it is so far removed from this that a line prolonged downwards falls beyond the feet; the man then falls, unless, by bending his body

and bringing the added weight nearer the centre, he keep the line well within the space which his feet cover. In the distribution of weights, then, the first rule is to keep the weight near the centre; hence the

Fig. 24.

New Experimental Equipment. Front View.

old mode of carrying the soldier's greatcoat, viz., on the back of the knapsack, was a bad one, as it put on weight at the greatest possible distance from the centre of gravity. These principles are embodied largely in the present equipment, which has the advantage of being

light and simple. The ammunition is carried in four pouches and in the bandolier. The mess-tin is carried either on top of the greatcoat or under it when this is carried on the shoulders; or it may be fastened to the

FIG. 25.

New Experimental Equipment. Rear View.

waist-belt; in each case it can be detached without interfering with the rest of the equipment. The most objectionable feature of this present equipment is the bandolier, which when loaded with ammunition presses heavily on the man's chest.

In spite of its superiority over earlier types, it is probable that this equipment will undergo further amendment and improvement, notably by the substitution of webbing for leather. In fact, the equipment of the future will be more or less as depicted in Figs. 24 and 25. This equipment is simple in construction, light, durable, has no straps crossing the chest, and can be rapidly put on or off. It allows of the waist-belt being unfastened on the march, and even when taken off will remain completely assembled. It permits of a reasonable quantity of spare kit being carried on the march, and, if necessary, allows of the kit-carrying portion being readily discarded, leaving the wearer with his fighting essentials only. The main defect of this equipment is that it is very hot. Its weight alone is 4 lb. 13 ounces, and with a maximum ammunition capacity of 150 rounds, represents a total load, without spare kit and entrenching tools, of over 15 lb.

A practical trial has been also made of an equipment designed on the "rucksack" principle. The idea upon which the rucksack is based is to afford each man a light and serviceable receptacle in which he can carry the whole of his authorised field-kit other than his arms, ammunition, and water-bottle. If circumstances, such as an impending action, render such a course desirable, the rucksack and its contents can be discarded immediately, only indispensable articles, such as arms, ammunition, and water-bottle, remaining to be carried. The rucksack as issued was of the Alpine type, and consisted of a rectangular bag of material, the approximate dimensions of which are 17 by 17 ins. The mouth of the

bag, which is situated at the top, is closed by a running cord, and two pockets are externally attached to the rear face. The lower and larger one is intended to hold the mess-tin, and the upper one the grease-tin and any other small articles. The main portion of the bag carries the greatcoat, folded or rolled, also any spare or extra ammunition. The rucksack is carried by means of two web straps joined to the top and bottom corners of the sack. The arms are passed through these straps, and the latter rest on the shoulders. When it is remembered how necessary it is for an infantry soldier to have an equipment giving expansive carrying power, either for food, ammunition, or clothing, the utility of this form of valise cannot be called in question.

The advantages of the rucksack are that it can be taken off or put on in a few seconds; further, when marching or when halted the coat can be unbuttoned from top to bottom without disturbing the equipment. There is nothing hanging about the man to impede his movements, as the load is compact and out of the way. The wearer's arms are free, and his shoulders are not tied down to his belt by straps, as is the case in the ordinary form of equipment. The sack can be carried easily over the greatcoat, and itself has a carrying capacity much in excess of any other article of the kind. In packing the rucksack it is important to keep the weight at the bottom. Let everything be flattened down well; the better a rucksack is packed the better it rides. The carrying straps should be kept long, so as to allow the weight to rest, so to speak, on the buttocks.

It is unlikely that the rucksack will come into use with European troops, as its best features are embodied in the other equipment already mentioned. For native troops, however, the rucksack type presents many advantages.

Work of the Soldier.—This is difficult to estimate, but depends on the branch or corps to which he belongs, and therefore it cannot be brought under one general description.

The artillery have the hardest work, which comprises mostly cleaning horses, guns, carriages, and stables. The cavalry have very nearly the same amount of work to get through, although their stable duties consist nearly altogether in looking after their horses, but their movements on parade are more rapid, and the distances they cover are greater. The infantry duties are mostly confined to drills, marches, and fatigue work in barracks.

All these duties, when not excessive, have a beneficial effect, but when severe and violent work has to be done hurriedly the soldier is not placed in the same favourable condition to carry out the work as the ordinary mechanic would be; this is largely due to the fact that in the drills the position is more or less strained, while the nature of his dress and equipment adds to the work which a soldier is called upon to do.

With a view to assist in the physical development of the soldier, every recruit is ordered to have a three months' course of gymnastic training. Admirable as the theoretical intention is of stimulating the physical development of the recruit by setting up drill and

gymnastic exercises, there is unfortunately much evidence to show that its practical results are not free from criticism. This matter has been discussed in chapter vii. The attention directed to this subject will probably bear fruit in some much-needed modifications of the gymnastic course, but no course of physical training can hope for success unless planned on a physiological basis and conducted by instructors who themselves have some elementary conception of the two functions of the heart and lungs. That the conditions of service life are the prime and only cause of the irritable state of the heart in so many soldiers is emphasised by the fact that it passes off gradually when these men revert to civil life.

CHAPTER XII

THE MARCH AND THE CAMP

THE hygiene of the march and the camp is a matter which deserves the earnest consideration of every soldier, as apparently trivial mistakes made under these circumstances have often far-reaching effects. Further, these mistakes have reference to a variety of details, some of which are intimately concerned with the acts of the individual, while others are essentially within the sphere of control of the administration.

THE MARCH

Preparation.—In preparing for a campaign or long march it is important that all cases of disability should be segregated and left behind, since such soldiers are certain to break down sooner or later and become encumbrances to the marching column. Especially does this apply to the detection and elimination of concealed or partially cured venereal disease. Great care, therefore, must be taken that only fit and sound men are permitted to join the columns. The next essential preliminary to every march is to see that the men do not start on empty stomachs. We do not advocate the issue of a heavy or large meal before commencing a

march, but rather the consumption of light refreshment, such as tea or coffee with bread or biscuit; this is particularly desirable when the men break camp and move off in the early dawn, as at such times a little food with a warm drink does much to lessen fatigue and increase resistance to disease.

Time and Length.—The hour of starting on a march and the length of the march are matters upon which any definite rules are impossible, since any movement of troops is largely influenced by weather, roads, and military necessity. The custom in our service is to march in the early morning; the men are fresh, the air is cool, and the main effort can be completed before the heat of the day comes on. Marches at night are rarely necessary, and our own experiences of marching at night are distinctly unfavourable. Any attempts to repeatedly march at night invariably result in an increase of sickness. Except under the stress of military necessity, the loss of sleep and general discomfort occasioned by such night marches may be considered to far outweigh the ordinary advantages to be gained thereby. As to the length of the march, a fair day's effort for infantry under usual conditions may be said to be from twelve to fifteen miles. Of course much more than this can be and has been frequently done, but the above expresses the reasonable limit; a greater average than fifteen miles daily is rarely achieved, except by small bodies of men and for short periods. The severity of the march is not to be measured so much by its mere length in miles, but rather by other factors, such as pace or time in which done, load carried, and formation or position in the column.

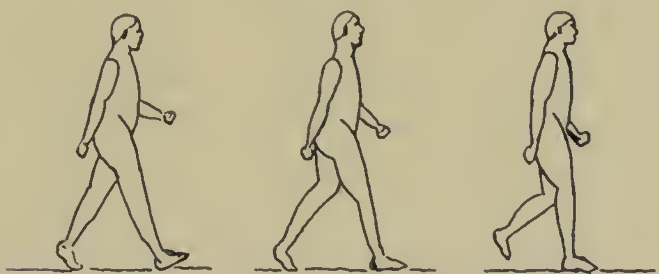
Speed and Step.—The rate of speed and individual ease with which a march can be done depends largely upon the size of the command.* An infantry regiment will accomplish a fifteen-mile march in a trifle under six hours, but a brigade will need nearer seven hours for the same distance, and a division will require eight or nine hours. The question of individual ease when on the march is further complicated by the fact that the movements of the soldier are to a certain degree unnatural and constrained. It is true these disabilities are much less manifest now than formerly, but even so the weak man has to keep up with the strong, the man of short stride with the one of long, and the very regularity of the step tends to make military marching wearisome. The observations made in chapter vii., when discussing the physical training of the soldier, have an important bearing upon the act of marching, and the principles there explained should be steadily borne in mind. As far as possible the movements of the individual soldier should not be impeded by restrictions of an unnecessary nature, and every endeavour made to turn what is a compulsory military movement into a salutary and stimulant exercise.

In spite of notable changes for the better in marching methods, the attitude and carriage of a soldier marching still present certain artificial characters which make the service marching step compare, as a means of locomotion, unfavourably with the corresponding pose and gait of ordinary walking. Under present methods of marching the shoulders must be kept straight and the neck and body erect; the knees are only slightly bent,

* "Combined Training," section 25.

and the feet are thrown out well in advance of the body, the free arm swinging naturally (Fig. 26). In ordinary walking the heel touches the ground first, the greatest weight being borne by the flat of the foot, and the toe leaving the ground last. Too often the soldier is taught or acquires the habit of placing the foot almost flat upon the ground, thereby increasing the shock of impact and personal fatigue. It must be remembered

FIG. 26.



Ordinary or Straight-leg Marching.

that the foot acts as a lever of the second order, in which the bases of the toes are the fulcrum, the muscles of the calf attached to and hauling on the heel are the power, and the resistance is the weight of the body transmitted by the shin bones on to the ankle joints. In ordinary marching the toes should be directed well forward, so that the thrust backward in the foot should be in the direction of its length, and not across it. Anatomically the foot is an arch supporting the weight of the body on the heel, the outer portion of the sole, and the ball of the toes; the inner portion of the sole in a well-formed foot is concave, and not coming normally in contact with the surface over which the person moves. The more the foot is everted the less

is the body supported by the outer surface of the sole, and the greater the tendency to break down the plantar arch of the foot. The soldier should be taught to restrict the outward inclination or eversion of the foot. A moderate inclination of about 10 degrees probably best answers all requirements, as it favours the broadest basis of support with the maximum of claw-like propulsive movement from the toes. Any excessive raising of the feet involves loss of power. The foot should be raised from the ground only so far as is necessary to clear obstacles.

More attention might be directed in our army with advantage to a cultivation of the marching method much practised in the French army. In this step, known as the "pas de flexion," the hips, knees, and ankle joints are slightly bent, the body being inclined forward and the feet placed on the ground with little emphasis. This mode of progression resembles the lope or shuffle affected by many semi-civilised races. The vertical elevation of the body by the flexion method of marching is barely one inch, while in the ordinary step it is a clear two inches. This difference represents an economy of energy in marching a mile equivalent to raising the individual through a vertical distance of 150 ft. In flexion marching, owing to the forward bend of the body, the centre of gravity is constantly on the point of being lost, and the only way to prevent falling forward is to keep in motion (Fig. 27). To keep pace with this movement forward the foot should be raised only slightly and brought into contact with the ground glancing rather than flat. To train in this method, short, quick steps, 160 to the minute, are at first required, their

length being increased gradually. The French begin by teaching the men to cover 3000 yards in this way, increasing it to 12,000 yards. In three months, with three practices a week, the French can get a fully equipped soldier to cover twelve miles in a hundred minutes, which is at a rate of about seven miles an hour.

The length of the natural step varies with the height of the individual, but probably should not exceed six-

Fig. 27.

Flexion or Bent-knee Marching.

sevenths of the height of the limbs, and, taking the average of a number of soldiers, is about 27 ins. The regulation length of the step in our army is 30 ins. at the rate of 112 to the minute. In the French army the length of the step is 29·5 ins. and the cadence 120 per minute; in the German army the length is 31 ins. and the rate 112 to the minute. It is doubtful whether the cadence should be ever increased beyond 120 per minute, since what is gained in number is lost in the reduction of the length of the step. Since the official marching step is somewhat in excess of the length of the natural step of the average soldier, it is advisable to let men make or take their own step; as a matter of fact this is usually done, experience showing

that most men can increase more easily the number than the length of their steps. Where weights or loads are carried the steps must be shorter. This question of the load or equipment has already been considered, and obviously has an important bearing upon the facility with which men will be able to complete a march. At the present time we do not think the British soldier suffers any serious disability under this heading. The question of formation and position in the column are details of great moment to the individual. On dusty roads close order becomes particularly trying to the foot-soldier, and for this reason it is a general rule in our service that infantry on the march should preserve a wide front and as open a formation as possible, in order to avoid the effects of crowding. Without ventilation through the ranks the air soon becomes very foul.

Mental Occupation.—Few things harass troops on the line of march more than straggling. It is an evil which rapidly demoralises the men, and needs to be firmly controlled. Its prevention depends upon a careful elimination of the sick, the encouragement and assistance of the tired, and the application of suitable measures to the undisciplined and lazy. To occupy the minds of the men on the march is probably the surest way of preventing fatigue; to this end a band or singing does much to lessen the tedium of the journey. The encouragement of choral singing among soldiers is a matter which deserves every support, and the excellent results following its practice are to be seen in both the Russian and German armies.

Foot-soreness.—In the conduction of a march various other conditions may operate to impair the

efficiency of the command. The most frequent and notable are the effects which follow exposure to extremes of heat and cold and the results of foot-soreness. The former can be safeguarded by the exercise of intelligence and foresight on the part of the administration, more especially as to selection of time and length of the movement, as well as of clothing and equipment to be carried. The proper care of the feet, while rightly within the purview of all officers, is mainly a matter for the individual soldier. Military statistics show that some 25 per cent. of troops on field service sustain more or less injury to the feet as a result of the first few days of marching, and, under the best circumstances and with all precautions, constant marching must be expected sooner or later to render a considerable proportion of an infantry command unfit for duty. Ill-fitting boots and socks, combined with uncleanliness of the feet, are the real causes of this disablement of the marching soldier. The ablution of the feet at least once daily should be made compulsory for troops in the field. If facilities for complete washing of the feet are not available the thorough wiping with a wet cloth, particularly of the toes, answers an excellent purpose in the removal of dirt and grease. Excessive sweating of the feet may be relieved by bathing in ½ per cent. solutions of formaldehyde. For the same purpose a 2 per cent. ointment of salicylic acid made up with tallow or vaseline is recommended, or a powder made up of the following ingredients: Salicylic acid, 3 parts; starch, 10 parts; powdered talc, 87 parts. These remedies are at best but palliatives; the real remedy lies in the provision of a well-fitting boot

and a soft, smooth sock to cover the foot. This question is generally well understood and appreciated by the soldier, who realises that for the prevention of injury to the feet by marching three factors must ever receive consideration; these are the elimination of soldiers with badly formed feet, the issue of well-fitting boots and socks, and the enforcement of cleanliness. The ensurement of attention to these details is only to be secured by daily personal inspection by the company or unit commanders.

Water Discipline.—All soldiers, especially recruits, are prone to drink as often during the day or on the march as they approach usable water; similarly, a too free recourse to the contents of their water-bottles is a common fault among even experienced men. While arbitrary control over the use of the water-bottle on the march is unwise and impracticable, still it is well to explain to the men the advantages of husbanding their resources and of developing a proper sense of water self-discipline. Much can be done to prevent the sensation of thirst by carrying some small hard object in the mouth, as a pebble, to excite the flow of saliva. To the same end, breathing through the nose rather than through the mouth should be encouraged, while tobacco-chewing, and to a less degree smoking, is inadvisable on the march as tending to increase thirst. The men's water-bottles should invariably be filled with approved water before starting on the march, or they may be filled with unsweetened tea or coffee. At all halts near water the quality of the same should be determined by the medical officer, and on his verdict or advice should depend whether the men's bottles are

refilled or not at that source. The various modes suggested for securing an approved water for soldiers on field service have been discussed under the general heading of water-supplies in chapter ix. Mention may, however, be made here of the paramount importance of all officers exercising a careful supervision as to the general cleanliness of the men's water-bottles and the regimental water-tanks. The successful carrying out of this detail presents difficulties, but they are not insurmountable, provided trouble be taken and some initiative displayed. Were the acid sulphate of soda tablets in general use the water-bottles would then be automatically cleaned. Washing out with boiling or very hot water is the most rational method of cleansing these bottles, but on field service or manœuvres this is impracticable, owing to the lack of sufficient hot water. For similar reasons, the use of permanganate of potash or other chemical is not always a practical procedure.* Probably, the best thing to do is to fill the bottles at least once a week, or oftener if possible, with very hot tea, and cause this hot liquid to be retained in the bottle for at least an hour. Hot tea is available for the soldier in nearly every camp, and if used periodically as a mere means for washing out the water-bottle would do much good; but to be of any use the tea must be poured into the bottles in as near a condition of boiling as possible. The practice of attempting to scour out the inside of a bottle by placing stones, sand, or gravel in it and then shaking, followed by washing out with water, should be discouraged. It is difficult to safeguard the cleanliness of the stones or sand, and too often

* "Field Service Pocket-book," 1907, p. 38.

the last state of the water-bottle will be worse than the first. Under circumstances where there is an ample supply of clean or safe water the ordinary washing out by three or four fillings with this water is a reliable procedure, but to be of any use this and all other similar methods must be carried out under the intelligent supervision of an officer. To leave this matter to the personal initiative and care of the ordinary soldier is but to court failure and to engender a false sense of security. Water should never be kept in the water-bottle when the bottle is not in use. The Italian pattern bottle, however, requires periodical soaking to prevent it from becoming too dry.*

The Halt.—During marches, regular halts are necessary in order to rest the muscles and to give men the opportunity to ease themselves. In our army these halts are generally for five minutes in each hour, while on marches of more than twelve miles in length a halt for half an hour is made usually half-way. Prolonged halts are often risky, particularly in hot weather, as the men soon get chilled. The most important sanitary question connected with all halts on the line of march is the need of sanitary police to control and prevent the reckless fouling of the immediate vicinity of the halting-place by men who retire to ease themselves. Too much stress cannot be laid on this point, as its neglect in the past has been the cause of much preventable tronble. The essential need is for the officer in command to allocate areas of ground where the men may resort, and to place pickets or sanitary police over these places to see that the men, using the same, cover

* "King's Regulations," 1908, para. 1717.

up with soil all excretal matter deposited there. The covering of this material with earth need be no elaborate work, nor involve any greater effort than the preliminary scratching of a shallow hole with the point of the boot or sword, bayonet or stick, and the depositing of the excreta in this shallow depression, taking care on completion of the act to cover the ordure over with the displaced earth. The personal labour demanded of the individual to carry this detail out is nothing, while the results that would follow its completion in the aggregate are far-reaching. In place of having these halting-places, where regiments and marching columns have halted, loathsome centres of pollution, they would be relatively clean and odourless, while as foci for the spread of infection their capabilities for evil would be relatively small.

An alternative method is that the sanitary section men should accompany battalions or other units on the march, in the proportion of one sanitary section man per two companies. This man to carry a spade. Regimental standing orders should insist that: (1) All men must cover their urine or excreta with loose earth, scraped up with a bayonet, a sword, or a boot. (2) Men, except in very urgent cases, must not be allowed to fall out between halts. (3) At short halts, say for under half an hour, the sanitary section man should report to the senior company officer of the two companies to which he is attached, who will indicate to him a suitable place to which the men falling out must go. The sanitary section man must at once proceed to this spot, accompanied by the men wishing to fall out. He will either himself cover up their urine and excreta with

the spade which he has, or see that the men themselves do so by means of the spade which he carries for the purpose. No men should be allowed to rejoin their companies or column until this material is so covered up. (4) When halts are for longer periods than half an hour, or when outposts are placed, the sanitary section man must proceed as directed above to the spot intended for easement, and there dig a few short, shallow trenches for defæcation, and one shallow trench, some three inches deep, as a urinal. The enforcement of these orders should be carried out rigidly, and no halting-place left without the orderly officer of the day personally visiting and satisfying himself, for the information of the commanding officer, that the halting-place has been left in a wholesome state. Failure on the part of the men to carry out these orders should be made a matter of discipline, and entail corresponding consequences.

There can be no doubt that a reform in our practice at halting-places is urgently called for, if only to check or prevent the wholesale fouling of wayside areas where marching columns halt. The remedy is comparatively simple, involves little personal effort, and is limited to an attention to details as explained. It is purely a question of discipline, and until this view of it is realised and put into practice the evil will continue. An appreciation of both the evil and its remedy constitutes one of the most urgent sanitary reforms in our army. Its fulfilment can only follow the awakening of a sense of sanitary responsibility in the officer, coupled with intelligent obedience and co-operation on the part of the man.

The use of alcohol in any form should be forbidden

absolutely on the line of march. If ever such an issue be deemed permissible, it must be so only at the end of the march or when the day's work is over.

The Camp

All camps may be regarded as so many canvas towns, in which the tents and huts represent so many houses. The selection of a camp site is largely dominated by the facilities which exist for obtaining water—this is particularly so in regard to temporary camps; but where camp sites are likely to be occupied any length of time the feasibility of bringing the water to the camp must be as much considered as taking the camp to the water. The proper location of a camp, as a matter of the greatest importance in maintaining the health and efficiency of soldiers, demands intelligent consideration. It is a good rule to select the site as if for continued occupancy, since it may happen that the intended bivouac becomes, through necessity, a camp of a more or less permanent character.

Camp Sites.—When possible, camps should be placed on high ground, since not only is the surface drainage better, but exposure to air currents facilitates evaporation. Situations at the base of hills are usually unhealthy and damp, as the ground-water, coming from a higher level, is checked in its flow and often forced to the surface. Such a site may be acceptable if a deep transverse ravine intercepts the drainage from the high ground behind it. No camp should be placed in ravines or dry beds of water-courses.* Low plains surrounded by high land are notoriously objectionable.

* "Combined Training," section 34.

Similarly, valleys and punch-bowl depressions are often hot and damp. The vicinity of marshes, rice-fields, or irrigated lands, as well as areas periodically under water, are always dangerous to health, and favourable to malarial infection, owing to prevalence of mosquitoes and gnats. Should the placing of a camp near a marsh or irrigated area be unavoidable, rising ground or a screen of trees should, if possible, be made to intervene. Localities at the mouths of rivers and places to which surface- or subsoil-water gravitate are always undesirable, for obvious reasons. An abandoned camp site should never be utilised except under circumstances of great necessity. Old camp grounds must be considered as more or less permeated with the organic soakage incidental to human occupation. Soil contamination is certain, and there is a strong probability of its specific infection. As regards actual soil, it may be said the more porous the better, but if a camp must be pitched upon an impermeable soil like clay or rock the locality affording the best surface drainage should be chosen. Newly ploughed land should be avoided; so, too, should very dusty areas, as dust is not only a vehicle for the dissemination of micro-organisms associated with disease, but also contributes largely to the discomfort of all in camp, and indirectly impairs sanitary discipline by engendering an indifference to personal cleanliness. In the selection of camp sites, apart from the question of water-supply, the golden rule to follow is: choose areas which are not only dry, but clean—that is, have not been occupied recently for other encampments, and are not fouled or in any way encumbered with the recent filth of man and animals.

Water-Supply.—The general principles affecting this question have been considered in chapter ix., and need no detailed discussion in this place, except it be to emphasise the fact that it is the first duty of the commanding officer, on forming or occupying a camp or bivouac, to secure and protect the water-supply. The question of the quality of the water available will be determined by the officer of the medical corps in sanitary charge of the command, and in accordance with his verdict and advice action must be taken as to treatment and general distribution. The protection of the supply from pollution permits of no delay; action must be prompt and thorough, involving the placing of picquets to warn off unauthorised access, and, where only one source of supply is available, to prevent pollution by animals drinking before the men's supply has been drawn. Where the circumstances permit, water for animals should be taken at a point distinct from that supplying men; in the case of running water the animals' drinking-place must be below that whence the water for troops is taken. When moving into new country, where the nature and quality of the water in wells and streams is unknown, every command should send forward with its advance parties an officer of the medical corps, equipped with simple reagents, who, after making a rapid estimation of its character, should affix an official label or notice indicating whether it be sufficiently good to drink untreated or whether it requires purification before issue. The principles and practice of water purification have been discussed elsewhere (p. 159).

Where surface-water is the source of supply it

should not be forgotten that it is extremely liable to pollution, and hence a careful inspection of the surroundings is of paramount importance with a view to the proper location of the various details which constitute the command. Under all circumstances every effort should be made against waste, pollution, and the turbidity which results from trampling the margin of a surface supply into mud. If the camp is of any permanency and the water be derived from a stream the approach should be paved and so located that the water may be drawn from the main current, and not from the sides or from a foul eddy. If the supply be at all limited the water will be best given to animals by receiving it first in troughs, as by so doing less disturbance of the stream results.

Where a spring or springs is the source of supply a box or barrel should always be sunk in the spring head, to prevent fouling of the water through its disturbance during removal. If likely to be used for any length of time, a spring should be enclosed, its level raised, and the ground made to slope away from rather than toward it. If this is impracticable the vicinity should be so ditched that all surface drainage from higher ground is intercepted and conducted to a point below the level of the spring. The latter may need to be frequently cleaned, and all accumulations of leaves or *débris* removed. In the case where wells are the source of supply the essential precaution to take is the safeguarding them from surface pollution. If they are covered this is comparatively simple, but if uncovered special picquets may be needed to prevent access of unauthorised persons and the utilisation of such

places for ablution purposes. In commands consisting of both Europeans and Orientals or native races it is advisable, if circumstances permit, to allocate certain wells exclusively to whites and others to natives.

In camps water is usually carried from its source to the lines in water-carts, or in tanks on wheels, but other vessels, such as pails, canvas tanks, barrels, chatties, and skins, are used. In all cases the greatest care is required to keep these receptacles clean. This is by no means easy to do, and whether it is done must depend largely on circumstances. There is no simple procedure, and virtually the only all-round useful method is the washing or flushing out with ordinary water made a deep red colour by means of permanganate of potash, repeating the process so long as the water fails to remain of a pink colour. Without going so far as to say that this will sterilise these receptacles, we can affirm that it will destroy the greater number of contained bacteria and render them reasonably clean and wholesome. If water is kept stored in camp the vessels must be protected from dust and other contamination by suitable covers. Men should not be allowed to drink direct from the taps of water-tanks or from the rim or spouts of other receptacles used for carrying or distributing water.

The Camp Space.—Although certain regulations exist as to the manner and place of laying out various camps, it will be readily understood that these are subject to constant variations, owing to physical difficulties connected with the locality. The minimum camp and bivouac spaces allowed for various units or corps in

our service are shown in the following table. These, if worked out in terms of men per acre, do not show any

—	Cavalry Regiment.	Battery of Artillery.	Squadron of Cavalry.	Field Company, R.E.	Mounted Infantry Battalion.	Infantry Battalion.	Cavalry Field Ambulance.	Infantry Field Ambulance.	Cavalry Brigade.	Infantry Brigade.
Front in yards	165	75	55	35	200	65	63	120	500	375
Depth „	150	150	150	150	150	150	122	200	440	150
Men per acre .	80	76	66	220	65	330	99	94	35	262

excessive density of population on the gross superficies; but it is only when we come to note the extent of crowding together of men in individual houses or tents that we come to realise what life in camps really means to the soldier.* In this connection the following details as to the size of and accommodation afforded by various tents used in the service are instructive. The circular or bell tent gives a ground area of 176 sq. ft., which, divided among fifteen men, means a trifle over 11 sq. ft. each. In the British private's tent, commonly known as the E.P., the floor area is 320 sq. ft., or 20 sq. ft. per man. The larger-sized Indian general service tent gives a total floor space of 196 sq. ft., or 12 sq. ft. per man; the smaller type of the same pattern gives 14 sq. ft. if not more than eight men be placed inside. These figures show that with the full complement of men in various types of tent the superficial space available for each man may be as little as 11 and never more than 20 sq. ft. It is true many tents do not receive the

* See "Combined Training," sections 35 and 47; also "Field Service Pocket-book," p. 30 *et seq.*

maximum number of authorised occupants, but the space available is not only for the man, but his kit and accoutrements. Hence it may be computed that under the most favourable circumstances in peace camps the average soldier does not get a greater floor space than 17 sq. ft., while in camps during war the space available per man averages some 10 sq. ft. Under these conditions the excessive incidence of some diseases among troops and others living in crowded tents is not surprising. Many experienced officers advocate the disuse of tents for troops in the field, and let the men bivouac in the open. In certain climates this would be sound practice and be attended with the best results, but for encampments in this country, except in the height of the summer, we question whether the total abolition of tents would be permissible. Certainly the men might be taught and encouraged to sleep with their tents open; this would minimise risks. All medical experience goes to show that the risks attaching to exposure to vicissitudes of weather among well-fed and well-clad persons are comparatively small, and much overrated by laymen. On this question it can be affirmed that a field force without tents may be uncomfortable, but it will be healthy; on the other hand, a similar force with tents may be comfortable, but it will be less healthy. Whatever may be the rule in the future, tents or no tents, it is incumbent upon all to realise the risks attending the crowding of men together in tents, and to do their best to minimise the facilities for direct infection from man to man which tent-life does so much to foster. When men are billeted in civil houses or buildings for one night only the accom-

modation may be estimated on a basis of two men for each yard of room length. For longer periods of occupation only one man should be allocated for each yard of room length.

All tent walls should be looped up during fine weather, so that the tent area may be dried and disinfected by fresh air and sunlight. Even in cold and doubtful weather the sides of the tents should be tied up during the absence of the occupants. If removal to a new camp site or fresh tent area be not practicable, all tents should be struck and their enclosed ground area sunned or aired for a few hours every four days. In a properly arranged camp the intervals should be always sufficient to render the shifting of a tent to a new site possible. Where huts are used the doors and windows must be opened daily to permit of aeration and the entrance of sunlight, and the roof, if of canvas, should be turned back. The digging up or excavating out of the soil within a tent area should be discouraged as tending to impede ventilation and due cleanliness; if floor-boards are not available, then the ground may be covered with either straw or a tarpaulin, but whatever is employed it must be turned out and well aired and cleaned daily, so long as weather permits. Blankets and bedding must be sunned and aired each day, either by hanging on supports erected specially for the purpose or by spreading on the sunny side of the tent roof; the former plan is preferable, as it allows access of light and air to both sides of the article.

Another important practice is to discourage the men as far as possible from eating their food in their tents, and also to forbid the storage or retention of food in

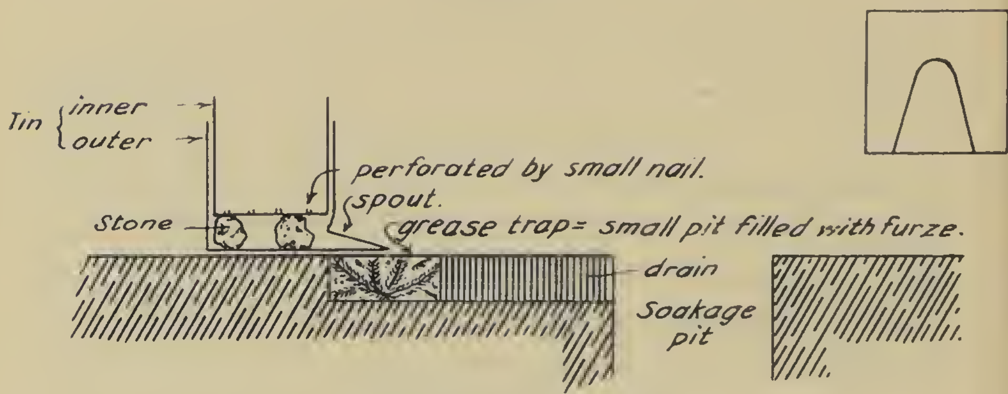
the tents. This is admittedly a very difficult question on field service, when the renewal of supplies is often precarious and the need of economy of what is available an urgent necessity. Still, every effort should be made to reduce the amount of stored food, particularly cooked food, to a minimum. If food must be retained, every endeavour must be made to keep it in closed tins or boxes so that flies may not gain access to it. This material attracts flies, is very difficult to keep sweet or clean, and in warm climates rapidly deteriorates. All food remains, particularly if not likely to be utilised in a few hours, should be either burnt or buried.

Kitchens and Ablution Places.—The cooking of food in camps presents no serious sanitary problems; at best it must be rough and crude. The most important details which need attention are: (1) That the kitchens should be located well away from latrines, urine pits, or other receptacles for refuse and garbage. (2) All sullage water must be made to pass into pits from which it can drain away along suitably dug trenches. This waste water is greasy, and if allowed to pass direct on to soil soon makes a felt-like scum, which attracts flies. A useful plan is to fill the reception pits or the upper ends of the drainage channels with coarse brushwood; if the greasy water be poured on to this mass of brushwood the grease and other organic solids are entangled, allowing the clearer liquid to run freely away. The brushwood, loaded with fatty matter, is conveniently burnt daily and replaced by fresh cuttings.

An alternative plan, which has been found to be good and easily improvised, is the following: Take two large biscuit tins, the upper acting as a coarse strainer, and the

lower serving to direct the water over and into a small pit, which, filled with grass, heather, or brushwood, acts as a grease-trap. From this small pit cut a shallow

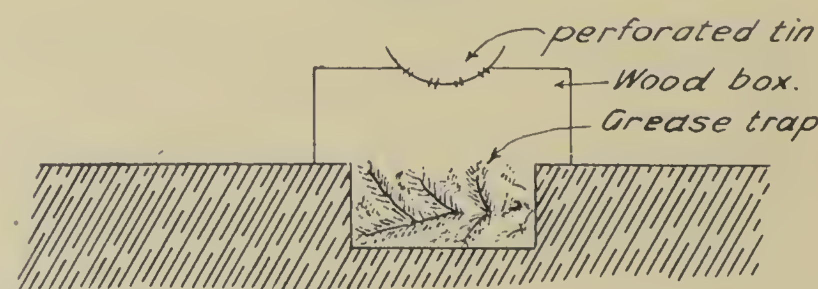
FIG. 28.



Improvised Grease-trap.

trench leading to a large soakage pit. The inner tin should rest on two or more stones, so as to allow an interspace. The spout from the lower tin is conveniently

FIG. 29.



Improvised Grease-trap.

made by cutting an inverted **V**-shaped flap from one of the sides, turning it down and rounding off (Fig. 28). Modifications of the foregoing can be made by turning a box upside down over the pit or grease-trap, the

bottom of the box being perforated with a hole, into which is fitted a cullender or piece of perforated tin (Fig. 29). A more elaborate improvised grease-trap is shown in Fig. 30. This can be made to discharge into either a special soakage pit or any convenient ditch. In all cases the furze, grass, or brushwood used to entangle or trap the grease must be burnt and renewed daily.

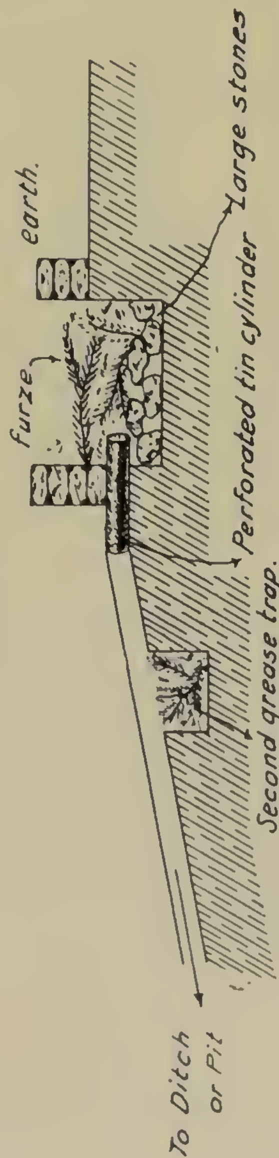


FIG. 30. Improvised Grease-trap.

Before leaving this question of kitchens and food supplies in camp it is desirable to note that the system of washing up cooking utensils needs careful consideration as well as amendment. In all camps a particular and separate washing-up place should be allocated. This should be provided with as much boiled or filtered water as circumstances permit. If sand is used for cleaning vessels, this should be previously baked over a fire. The whole process of washing up and sand-baking should be under the supervision of one of the sanitary squad men.

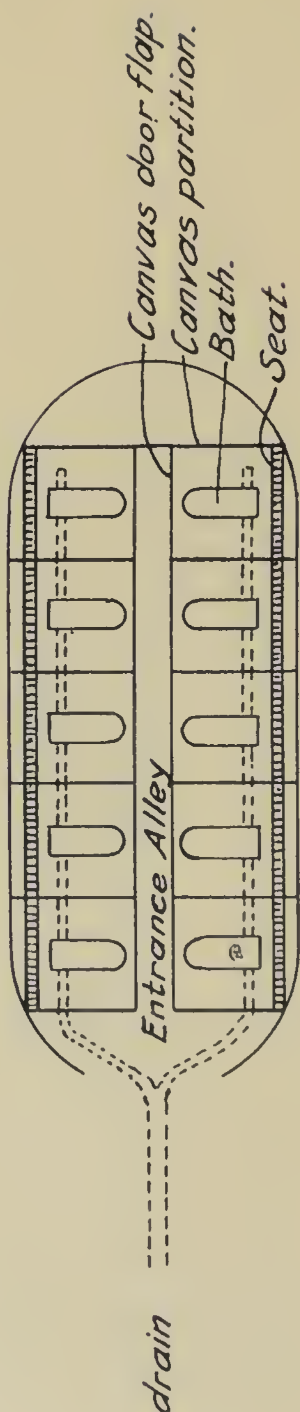


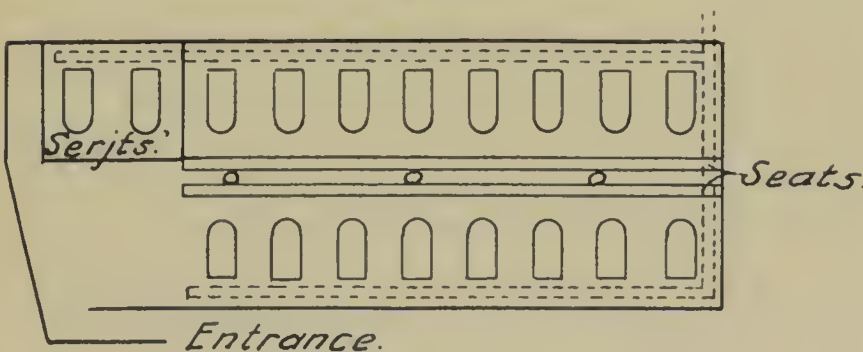
FIG. 31.
Improvised Bathing-place.

The ablution places need to be located conveniently near the men's tents, and the soiled and soapy water therefrom drained away and disposed of on similar principles to those indicated for kitchen sullage water. Where ordinary ablution benches with foot gratings are available care needs to be taken to prevent the adjacent ground becoming wet and sloppy. Much depends on the slope of the ground, but in cases where gradients are awkward, much can be done by banking up the lower end with earth and cutting a trench of suitable fall and depth to the other, from which a drain carries off the water. The trench may need to be covered.

In all semi-permanent camps more trouble should be taken to afford facilities for baths than is usually shown in respect of this matter. A very little initiative and ingenuity should

suffice. Thus a large tent or marquee can be divided by canvas screens, each compartment containing a seat, a foot grating, and a tin bath. The bath can be fitted with a wooden plug, which is made to discharge over a trough of galvanised iron (Fig. 31). Or, a temporary hut can be made of canvas stretched over rough wood supports. Two long seats should be arranged down the centre, with a suitable number of

FIG. 32.



Improvised Bathing-place.

foot gratings and metal baths; these latter can be emptied by tipping into a conveniently cut drain (Fig. 32). Even an ordinary bell tent can be used, placing in it six iron tubs, which can be emptied into a soakage pit, from which leads a drain to a larger pit outside. Unless some devices of this kind are resorted to, and more facilities afforded to the soldier in these fixed camps for obtaining a decent bath with some measure of privacy, it is futile to expect a high standard of personal cleanliness from him.

In standing camps, unless the physical condition of the soil and the gradients are distinctly favourable for a rapid absorption and soakage away of all sullage and

ablution water, it will be advisable either to shift the location of the kitchens and washing places every few days or to collect this liquid in air- and water-tight receptacles. Such receptacles should be placed on raised platforms for the better protection of themselves and the ground beneath them, and should be emptied daily and the contents disposed of outside the camp area. Before being returned to use they should be cleaned and smeared over with a cloth soaked in crude creosote oil.

Disposal of Refuse.—Kitchen refuse and the garbage and hundred and one things which go to make up the ordinary refuse from camps should never be thrown upon the ground. It should be invariably thrown into special receptacles conveniently placed for the purpose. In camps which are of a temporary nature these receptacles best take the form of pits, but where these are employed the contents must be covered over with at least 6 ins. of fine earth each day, the constant endeavour being to protect the material from flies. In more permanent camps all this garbage and refuse should be placed in closed metal receptacles, the contents of which are removed and disposed of daily, as explained for the sullage water. On no account, unless necessity compels, should the solid and liquid refuse be mixed. Carts or waggons for the removal of garbage to the place of disposal should be of special design, and capable of preventing any escape of their contents. The casual and too frequent mode of disposal of this waste material from camps to irresponsible civilians, who collect and cart it through lines and encampments without regard

to elementary sanitary rules, should be strenuously opposed.

The final disposal of kitchen garbage and camp refuse is a matter of great difficulty, particularly on field service; even in standing camps it is far from easy. The location of the place should always be outside the camp area, and placed to leeward of prevailing winds and remote from the source of water-supply. There are two possible methods, burial or burning. The former is suitable for cases where the amount of material to be disposed of is not excessive, but when much refuse is present the labour necessary to dig sufficiently large pits is almost prohibitive. In these cases destruction by fire is the only means of disposal; in fact, it may be said that burning is the ideal mode of disposal in all cases. Theoretically this is so, but practically it is difficult to carry out, mainly on account of the natural dampness of the material. In wet weather the difficulties from this cause are much increased. In the field, the methods for the cremation of refuse vary from the use of the company kitchen fire to the employment of specially constructed crematories. Various portable destructors have been proposed and used in camps. Probably the best is Horsfall's, but our experience with it has not been satisfactory, mainly owing to its weight and the difficulty of moving it; for fixed encampments it is eminently suitable. Munson * mentions a variety of crematories suitable for camp use, but from our own inquiries we learn that their general utility is not so great as was

* Munson, "Theory and Practice of Military Hygiene," London and New York, 1901, p. 395 *et seq.*

anticipated. Failing any special apparatus being available for the burning of camp garbage and refuse, ingenuity and common sense must be used as to the best method of effecting their combustion without offence.

Where crude mineral oil is available its incorporation with the more combustible material constitutes an effective aid for the destruction of garbage. In two

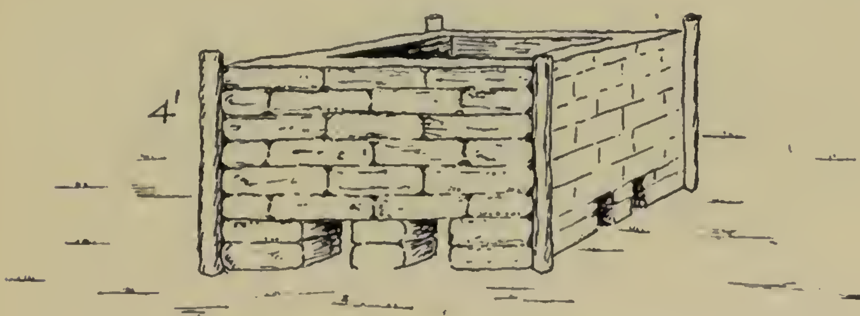
FIG. 33.

Plan of Improvised Camp Refuse Crematory.
(From *Journal of the Royal Army Medical Corps.*)

camps under our own control the construction of a simple grate by laying railway rails so as to form a grid or platform on lateral supports was eminently successful in maintaining a brisk fire, fed with camp refuse. In any devices of this kind the great essential is to secure a draught of air under and through the material to be burnt; and the damper the mass the greater the need of air. An improvised refuse destructor of a simple nature can be made by digging two trenches intersecting each other at right angles; each trench should be 9 ins. deep and any length from 5 ft. Over the angles of intersection a chimney or shaft is built up of sods of earth, a few pieces of iron

hooping or other resistant material supporting the chimney where its walls cross the trenches. A fire can be quickly lighted at the base of the chimney, and fed steadily by throwing rubbish and refuse down the top. Assuming the refuse be added with ordinary care and the patency of the draught trenches maintained by judicious raking, an enormous amount of combustible material can be disposed of in a few hours. Such an

Fig. 34.



Improvised Camp Refuse Crematory.

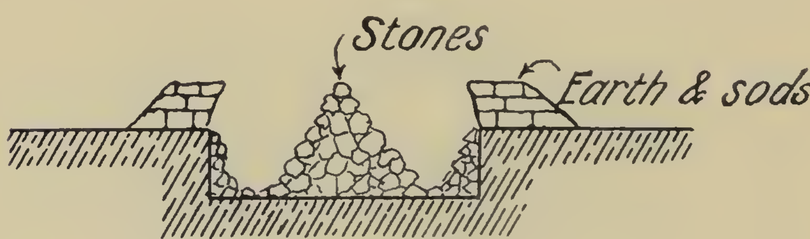
arrangement needs attention and care, but we have seen them work extremely well in India and at home.

Modifications of this type of crematory can be constructed as shown in Fig. 34, which is nothing but a rectangular refuse bin built of sods, with air inlets at the base of each side. Instead of being made rectangular, it can be constructed of cylindrical shape, with air inlets around the base. We have had considerable practical experience with them, and found them to be most efficient if properly supervised and intelligently fed. The essentials are to keep the air inlets raked out and not to feed too

quickly, especially if the refuse is damp. An alternative type is a horseshoe-shaped mound of earth encircling the burning material, taking care to place the mouth to the windward side. This is particularly suitable when the earth is peaty or loose and crumbly.

Another effective crematory is one mentioned by Arnold.* It consists of a circular pit 3 ft. deep and 15 ft. in diameter (Fig. 35). The bottom is covered

FIG. 35.



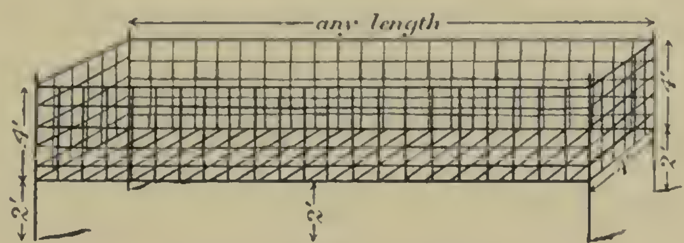
Camp Crematory.

with loose stones to the depth of a foot, and on this a circumferential wall is built up to the height of a foot above the ground level, the excavated earth being packed against it to prevent surface-water gaining access to the pit, and also to provide a sloping approach for tilting refuse into it. A pyramid of large stones occupies the centre to a height of 5 ft.; this is essential to provide a steady draught through the centre of the burning material. Ordinary wood must be used to start the fire, and after it is well burning it can be steadily maintained by adding refuse and garbage. The stones soon become intensely hot, and serve to dispose of liquid and damp stuff with

* Arnold, article on "Camp Sanitation," *Journal of Association of Mil. Surgeons of United States*, July 1905, p. 15.

great rapidity. This is an ingenious and most effective camp crematory, as we have demonstrated, but it is not of universal applicability; good large stones are a necessity, and they are not to be found in sufficient numbers in all places. Where they can be obtained we can testify to the efficiency of this device. In places when boulders or large stones are not procurable a similar crematory can be devised by using empty tins

FIG. 36.



Improvised Camp Crematory.

of all sorts and sizes; these are only too common in most camps. If not utilised in exactly the same way as suggested for the stone-made crematory, the tins may be stacked in heaps about 4 ft. high; upon and around these heaps should be piled the miscellaneous combustible rubbish, and the heap then set alight. The tins serve to keep an air space and generate an under draught, causing the whole heap to burn fiercely. The burnt tins can be used over and over again.

For more or less permanent camps large quantities of manure, litter, and general rubbish can be effectively burnt in a simple apparatus which may be described as a large trough made of wirework raised 2 ft. from the ground. Bands from forage bundles or any wire or pieces of ironwork can be utilised to make an arrange-

ment as shown in Fig. 36. Such a trough may be of any length, but should be 4 ft. wide and deep. It must be placed broadside to the wind, and the bars forming the bottom of it running from side to side, not lengthwise. The mesh is best made 5 ins. square, and a shelf of corrugated iron is an advantage if placed along the top to reduce spillage while litter is being transferred from the cart to the destructor. In this wire trough rubbish burns freely.

Disposal of Dead Animals.—Closely associated with the question of disposing of camp refuse is that of how to get rid of the carcasses of dead animals. This problem does not crop up during ordinary peace manœuvres, but in time of actual war assumes serious proportions. Here again two methods of disposal are possible, namely, burial and burning. We may say at once that unless special furnaces are available the burning of the carcasses of large animals is impracticable; it is difficult enough to burn the dead body of a single animal, but when it comes to having to cope with the carcasses of a dozen or more beasts, such as oxen, horses, and camels, the task is quite impossible. The only alternative is to bury, and even then this is far from easy. The time and labour needed to dig a pit to receive the body of a dead ox is appreciable, and when it comes to do the same for some dozen or more similar animals it will be readily understood that few units or commands can do it. What, then, is to be done? To leave the carcass to rot and decompose in the open is to establish a nuisance and general menace to the health of all around, and consequently not permissible. Under ordinary circumstances of warfare

the only course open is to disembowel the animals, bury the viscera as deeply as possible, and to leave the skeletal remains to be disposed of by nature. It is a crude proposal, but the only alternative. The defects of this procedure can to a certain extent be minimised by stuffing the eviscerated remains with straw or other combustible material and setting light to it. This will not consume the carcass, but it will do something towards drying it up and lessening the evils consequent on its subsequent gradual disintegration. We do not put this proposal forward as the ideal or desirable procedure; it is merely the least that can be done under circumstances of great difficulty. In many cases improvised crematories can be built up in which the bodies of animals can be burnt, and every endeavour to do so should be made in all camps. The final disposal of *all* refuse matter in camps should be under the direct control and direction of the sanitary officer of the command. His powers in this direction must be of the fullest, and, moreover, exercised with tact, firmness, and regard only for the sanitary interests of the individuals in his charge.

Disposal of Excreta.—We may now pass to a consideration of how to dispose of the excreta in camps and bivouacs. The proper disposal of this material is vital to the sanitary interests of all, but provided ordinary intelligence be exercised it presents fewer difficulties than might be expected. The moment a camp or bivouac is about to be formed or occupied the first duty of the commanding officer is to secure and protect his water-supply, and at the same time tell off a special detail for the location and preparation of latrines and

urinals. The construction of these necessaries must not be delayed until the tents are fixed and other camp duties have been performed; no matter how temporary the halt may be, the location and completion of these places is an urgent necessity demanding prompt action, and to be supplemented by the detailing of sanitary police to prevent surface contamination of the camp area by casual easement. Certain military circumstances are conceivable when the construction of latrines may be delayed ; under these conditions, to avoid surface pollution, some carefully selected spot must be marked off for the reception of dejecta, and sanitary discipline enforced to see that to this spot only do the men resort. At the earliest opportunity all excrement so deposited must be buried or covered with earth by the sanitary police. The general location of latrines will depend upon the direction of the prevailing wind and the position of the water-supply, the rule to be observed being, to leeward of the camp and in such a position that no possible fouling of the water-supply can result. The exact position of these places should never be left to the discretion of any officer other than the sanitary officer, or such officer of the medical corps as may be detailed for sanitary supervision of the command. Latrines should be as far removed from the tents as is compatible with convenience ; under ordinary conditions this may be put at 100 yards. The latrines should be placed as far as possible away from the kitchens and other places where food is prepared or stored. The extent of latrine accommodation in camps will vary according to whether the area is for temporary or permanent occupation ; in bivouacs it should be 3 per cent.,

for ordinary camps occupied for a few days it should be 5 per cent., and in those intended for longer occupation at least 8 per cent. These figures may be taken to represent either yards or actual seats, according to circumstances. The multiplication of latrines is undesirable, as one or two fairly large ones are easier of control than several smaller ones, and soil pollution is also more localised.*

In permanent camps, latrine accommodation will best take the form of pail-middens with dry earth, fitted with rough wooden seats, and organised on the plan and principles discussed in chapter viii. For the reception of urine iron tubs should be provided, these being placed adjacent to the ordinary latrines for day use, and during the night at selected points convenient for the tents. The contents of these several receptacles will need daily removal in covered and water-tight carts to points well away from the camp area, to be disposed of by burial in the earth. If portable middens, such as pails, are not provided, then the seats must be placed over pits or trenches specially dug. Whatever form the latrine takes, its successful conduction depends absolutely upon rigid adherence to the rule that the excreta must be quickly and completely covered over with earth, and this depends, again, upon the enforcement of individual sanitary discipline, adequate *personnel*, and competent administrative control and supervision.

For ordinary or more or less temporary camps the usual latrine is a trench, provided or not with a seat. Some 20 ft. of trench, 2 ft. deep, and 16 ins. wide, is the common allowance for each hundred men. The

* See "Combined Training," section 46.

great difficulty about all latrines of this kind, no matter whether they have seats or not, is the fact that the front edge of the trench soon gets wetted with urine, and the front of the latrine rapidly becomes a urine-sodden quagmire, the mud from which gets carried back into camp and tents on the men's boots. In the not remote chance of there being one or more undetected cases of enteric fever among the command, the possibilities of infection from this source are not difficult to imagine. To remedy this our later practice has been not to dig one long trench into which the men can ease themselves, but to dig a succession of short trenches in parallel, across which the user straddles, and readily directs both solid and liquid dejecta clear into the cavity, without soiling the sides. Each trench should be 3 ft. long, 2 ft. deep, and 1 ft. wide, and the interspace between each trench not more than 3 ft., —preferably less if the nature of the soil permits, so as to preclude the men using the trench otherwise than in the straddling attitude. Our experiences have shown these short trenches to be far cleaner than the old long type; they entail less labour to dig, and are more efficiently filled up and renewed. If available, a seat in the form of a stout pole can be laid at right angles to the trenches, supported on forked uprights. A back-rest may be formed by a similar pole, but is often omitted.

For camps likely to be occupied more than two days we are disposed to think that the old type of long trench latrine is better, in that it leads to a smaller area of ground being cut up and polluted, but in all more or less permanent camps a proper system of dry earth

latrines with buckets and suitable seats should be installed; the utilisation of the trench latrine, be it short or long, in any permanent camp is most objectionable. Every latrine needs to be surrounded by some form of screen, also roofed in if possible, and the soil removed from the trenches must be well broken up and carefully piled to the rear, whence it can be scattered as needed over the deposits. All displaced grass sods, too,

FIG. 37.

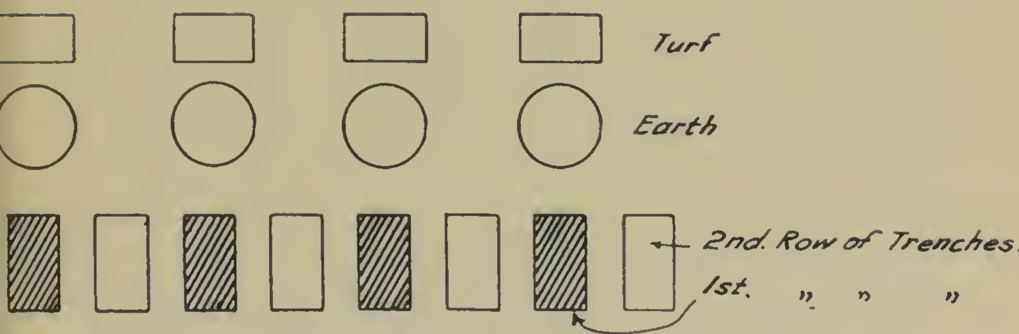


Diagram of Short-trench Latrine.

should be carefully stacked in rear of the loose earth, so that when the trench is filled in these grass sods can be replaced and the soiled area made neat and wholesome. All trenches should be arranged as far as possible in parallel lines. Where ground is limited, and the short trench is used, on the first series being filled in the next series may be made in the 3-ft. interval (Fig. 37). In wet weather latrines should be protected by a shallow drain to prevent the ingress of surface-water. Some kind of implement, such as one or more spades, scoops, empty tins, or tin-lids, should be by each trench for replacing earth. Kicking the soil in by the foot is certain to be a failure, and

should be discouraged as conducive to imperfect covering of the excreta, and consequent slackness. Men must be told the necessity for covering their dejecta; this precept cannot be told them too often. Failure on their part to adequately cover their excreta should be made a matter of discipline, and systematically punished.

The care of latrines and their proper administration is a most important factor in the preservation of the health of men living in camps or bivouacs, and yet it is a question which too many responsible officers are fain to ignore. No matter where the camp may be, and no matter what type of latrine may be installed, one rule must dominate the successful working of these places. This rule is that all excreta must be covered up as soon as possible with earth, not only for mere purposes of deodorisation, but to preclude the access to it of flies. One need not here dwell on the part which these insects play in the dissemination of filth and specific germs to food; it will suffice to say that to any exposed ordure flies will go, and it is our bounden duty to reduce the opportunities of their so going to a minimum. If the excreta deposited in latrines is to be covered over at once with earth, who is to do it? Each individual man covering his own discharges, or some special man or series of men to be detailed for this special purpose? Where ordinary earth-closets or pail-middens are fixed in camps there should be no difficulty in providing a number of boxes containing dry earth, with the necessary scoops, and so enabling each individual to cover his own fæcal deposit. In other camps where the ordinary trench latrine only exists the situation is not so simple.

In the first place, the available soil is less conveniently placed, the provision of scoops in sufficient number is out of the question, and the whole surroundings of the place conduce to a hurried rather than a leisured resort on the part of the individual. Experience shows that it is very difficult to get men to cover their excreta efficiently in these latrines. The only alternative is to place a man within the screen, provided with a spade, and direct him to cover each deposit with fine earth as each depositor moves off. A tour of such duty should not exceed two hours, and might well be limited to one hour. We have known instances where this system has been carried out by corps, and with excellent results, but the repugnance and opposition to the performance of such duty manifested by many men suggests that its enforcement in units where the discipline is not of the strictest will be difficult. In these cases what, then, is to be done? The only answer is, enforce discipline and compel the men to cover up their own excreta with earth at the latrines, and, moreover, place a sanitary patrol or policeman over the latrine to see that each man fulfils his duty to himself and his neighbour. So long as the sanitary foresight of the rank and file remains at the low level at which it is now, the latrine sentry, however great the sentimental objections may appear, is a necessity, and the only safeguard against enteric fever and other fæcal diseases which spread in camps from this point. The question then arises, where are the latrine sentries to come from? Are they to be drawn only from the sanitary squads, or from the unit as a whole? If the former, then their employment as such will have but

19

small effect in ingraining in the rank and file as a whole the obligations which rest on them in this matter. Clearly, the latrine sentry must come from the whole unit. The tour of duty would be short, say one to two hours, and the interval long. Apart from this, the practice will be the best means of imbuing the minds of all concerned with their own personal responsibilities in protecting the health of their own unit and the army at large. Consistent practice on these lines will soon lead to a marvellous change for the better in the care and management of these places; so much so that it may be confidently anticipated that, in place of being foul and putrid spots, the latrine will be no more offensive than an ordinary ablution place. When this is so, the incidence of filth-originated or dust- and fly-borne disease in camps will be sensibly lessened.

The care and conduct of latrines, whether in camps or barracks, must be ever regarded as a disciplinary matter, and unless it is so regarded these places will be foci of disease in all places and climates. The condition of all latrines should be verified personally by the orderly officer of the day at least once during each twenty-four hours. The tendency of the service is to delegate this duty to the quartermaster, who is not an executive officer. This is wrong both in theory and practice, and absolutely inconsistent with efficiency; we hope to see the custom discontinued. So soon as latrine trenches have been filled in to within six inches of the ground level their use should be discontinued, earth thrown in and well raised to mark a polluted site. To preclude the access of flies it is a practical point to see that the earth thrown on to the dejecta is fine and well-

crushed soil; the use of lumps and stones is unsatisfactory, leaving cracks and crevices by which flies get at the fæcal material. On the abandonment of a camp all latrine trenches must be filled in and the site marked as foul ground.

From time to time a variety of excreta crematories have been suggested, and Munson * speaks enthusiastically of several types. We have tried some, and cannot say they have been successful, except when dealing with small quantities of fæcal material. It must always be borne in mind that the combustion of excreta is intensely offensive, and readily gives rise to a nuisance, unless carried out well away from tents and buildings. For relatively small quantities of fæculent matter the forms of steriliser or destructor most practically useful appear to us to be those of Cummins † and Glenn Allen,‡ but neither is suited for general use by troops in the field.

In all camps, where ordinary receptacles are not provided, pits or trenches must be dug for the purposes of micturition. For day use these are best placed within the screen and adjacent to the other latrine trenches. Given a reasonably absorbent soil, the urine soon disappears, but it may happen that such will not occur; in this case care must be taken to see that supplementary pits are provided, while at all times the exposed urine-sodden soil should be covered at least once daily with clean dry earth to protect it from flies. For night use, when special urine tubs cannot be

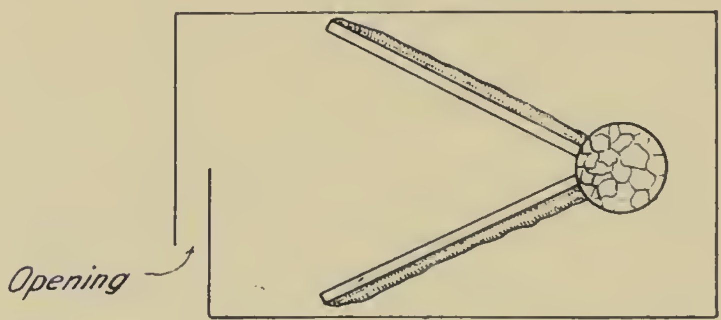
* Munson, *op. cit.* p. 399.

† Cummins, *Journal of the Royal Army Medical Corps*, ii. 287.

‡ Glenn Allen, *Journal of the Royal Army Medical Corps*, v. 606.

provided, or when the day urine pits are any distance from the men's tents, it may be necessary to dig shallow urine pits near the men's lines into which they can micturate at night. This is a practice which should be resorted to as rarely as possible, and needs to be zealously safeguarded from abuse ; at all times such pits should be carefully filled in at dawn. Urinals can be extemporised easily from empty oil tins, which may

Fig. 38.



Plan of Camp Urinal.

with advantage be partly filled with grass, chopped straw, sawdust, or any other absorbent material.

A variety of improvised urinals can be planned for camp use, according to circumstances. These will best take the form of shallow trenches leading into a pit filled with large stones, the trench being for urinating into and the pit to take the excess which fails to soak into the soil. Roughly, two trenches, each 6 ft. long will suffice for 600 men. The gradient should be a fall of 1 in. to the foot, and the width some 9 ins. to a foot. The catch-pit will vary in depth and size according to soil and number of men using the trenches ; one 3 ft. deep and 2 ft. in diameter in moderately porous soil should suffice for 600 men. The

trenches will last about two days, and the pit some ten days; when foul, new ones must be dug and the old ones filled in, and all grass sods replaced. Typical examples of these rough urinals are shown in Figs. 38 and 39; the trenches can be dug as radii from the pit, or as the hands of a watch. In some cases it may be feasible to screen off the pit, to prevent men actually

FIG. 39.

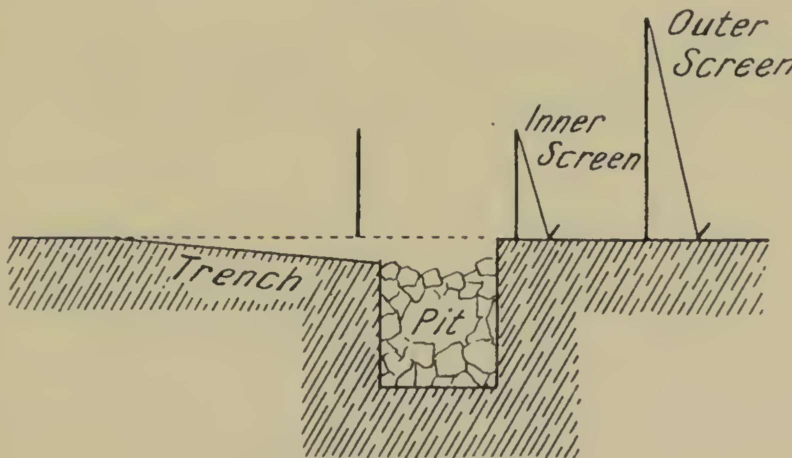


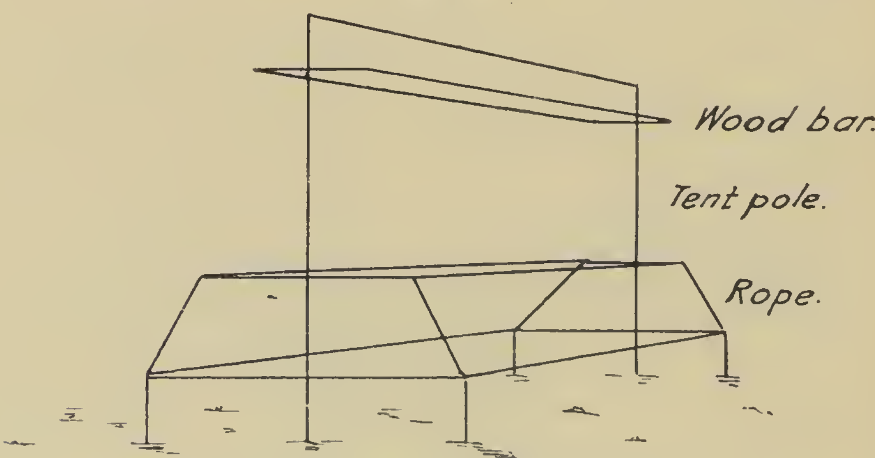
Diagram of Camp Urinal.

micturating into it, shifting the screen with the trenches, or, better still, cover the pit with sods, leaving apertures by which the contributing trenches may drain into it. Often the urine will not soak away rapidly; if so, one must either dig fresh pits or partly refill the pit with loose earth, when usually it will be found that the urine quickly gets absorbed.

Drying of Clothes.—There can be little doubt this question needs more practical consideration in camp than it has received hitherto. It is true the wearing of wet clothes conduces to much less ill-health than many suppose; still, a great deal of personal dis-

comfort could be avoided if some simple means of drying clothes on field service could be devised. The following method is deserving of note: Pitch as large a tent as possible, dig one or more holes, some 2 ft. deep, within the tent, sufficiently far from the poles and canvas to minimise the risk of fire. Line the holes with stones, and carry the stones up so as to make

FIG. 40.



Frame for Drying Clothes in Camp.

a rim or parapet round the hole some foot high. The stones must be fairly large, and the diameter of hole quite 3 ft. If a fire be lighted in the hole and carefully tended, the stones soon get quite hot, and radiate out a good heat. The wet clothing should be hung round the hole as well as the appliances on the spot allow, and the tent shut up. With a little care and initiative considerable numbers of wet garments can be dried in this way in a few hours. In place of a tent, a rough shelter can be built, or use made of an outhouse of some farm. An alternative procedure is to rig up a simple framework as shown in Fig. 40, either

within a large tent or under some rough shelter, and then place braziers full of wood ashes, improvised from buckets or tins, at suitable places near to the wet clothing.* These suggested methods are crude, but better than doing nothing to obviate the discomforts resulting from wet garments.

In closing this subject of the sanitary control of the march and the camp, it is desirable to emphasise the fact that much of its successful practice depends upon the exercise of care and personal initiative. This is required not only of the men, but of the officer; there can be little doubt that the men in all these matters will and must take their cue from the officer. Once they recognise that officers not only appreciate the importance of attention to detail in these matters, but are determined to see that it is carried out, their own attitude will be one of imitation. The essential principle of sanitation in the camp, as elsewhere, is *cleanliness*. This state of cleanness must not only be maintained while the camp is occupied, but on evacuation the camp area must be left sweet and tidy, so that those coming after may not suffer from a heritage of filth. Failure to understand and act up to this principle has been the cause of the loss of many lives in the past. The surest index of the cleanliness of men and places is the absence of flies, for if there is no dirt or filth to feed upon the fly will not be present.

* Some practical hints on this and similar topics are available in the sanitary report on manœuvres issued with Eastern Command Orders, dated February 6, 1908. To this report we are indebted for several illustrations given in this chapter.

INDEX

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